

**Testimony of David Albright,
President of the
Institute for Science and International Security,
before the Monetary and Trade Subcommittee of the Committee on Financial
Services**

**Hearing Title: “A Legislative Proposal to Impede North Korea’s Access to
Finance”**

September 13, 2017

North Korea’s September 3, 2016 nuclear test, its sixth overall and by far its largest in terms of explosive yield, demonstrates its resolve and commitment to developing a nuclear arsenal able to strike its enemies. During the last few years, North Korea has embarked on an intensive nuclear weapons testing campaign that has included three underground nuclear tests and tens of ballistic missile launches. Its apparent goal is to have a variety of nuclear warheads mated to ballistic missiles with ranges stretching to intercontinental distances. Few doubt that North Korea can now launch nuclear tipped ballistic missiles that can strike our allies Japan and South Korea. There is rightly more skepticism that North Korea is yet able to deliver a nuclear warhead to an American city.

I remain skeptical that North Korea can build a miniaturized two-stage thermonuclear weapon that it can deliver on an intercontinental ballistic missile (ICBM) to the continental United States. Nonetheless, this test appears to have achieved an explosive yield of over 100 kilotons, far larger than the yield of any of its previous tests. This yield is large enough to destroy substantial parts of modern cities. Whatever the specific design for this high yield weapon, this test is significant and requires extraordinary responses.

I still believe North Korea can be peacefully denuclearized. Accomplishing that goal will likely require exerting enormous pressure, starting with much harsher sanctions and trade cutoffs. The UN Security Council resolution passed on Monday is an important step in that direction. A priority is to far more effectively isolate North Korea from the regional and international financial system. Because many countries are not enforcing sanctions effectively, or are in some cases willfully disregarding them, punitive measures are needed to encourage compliance and deter violations. Additional U.S. legislation that supports that goal would be useful.

If pressure does not lead to successful negotiations, then it is better to have a further weakened North Korea and to make it more difficult for Pyongyang to create a functioning nuclear arsenal. In parallel, the United States needs to work with its allies in the region to build up defensive capabilities and increase deterrent postures. Today, the alliance among the United States, Japan, and South Korea is more critical and should be further strengthened. It remains imperative that those allies do not feel inclined to develop their own nuclear deterrent, further exacerbating regional security concerns and increasing the chance for nuclear war or miscalculation.

Substantive negotiations appear unlikely if North Korea continues its nuclear and missile testing efforts. Moreover, the United States should not grant additional concessions to North Korea. However, it should state to North Korea that it has a diplomatic path out of its isolation and sanctions if it commits to negotiate a full, verified denuclearization of its nuclear and long-range missile programs. Any such negotiation would need to repair past mistakes where North Korea was able to evade inspections and continue expanding its nuclear programs. An agreement would also need to allow unprecedented inspections and access, allowing for a full accounting of the program as part of a denuclearization pathway. Again, this prospect seems unlikely in the short term given the current trajectory, but it is important to keep available as a matter of U.S. policy in case increased sanctions convince North Korea to negotiate in earnest. Likewise, the Trump administration should continue to make clear that regime change is not its goal. The verified denuclearization of North Korea should remain the guiding U.S. policy, rather than piecemeal freezes with limited access in return for economic or other concessions.

Recent Test

The September 3rd nuclear test had the largest seismic signal of any of North Korea's six confirmed tests. The estimated yield of this explosion was about 100-150 kilotons, far larger than its earlier tests, which topped out at roughly 15 kilotons. This much larger yield, combined with North Korea's efforts to acquire capabilities to produce key thermonuclear materials, would suggest that this test was some type of thermonuclear device to increase the yield of a fission design. How it may have used the thermonuclear materials remains unclear.

We should view skeptically North Korean claims that this test was a two-stage thermonuclear device. Likewise, the picture of an elongated device distributed by North Korea purporting to show a miniaturized two stage H bomb is likely more aimed at spreading propaganda than something to be taken literally. North Korea understands our fears and is well practiced in the art of disinformation. I believe the object in the picture was a model meant to play on our fears of H bombs, sow division, and bolster their deterrent. In reality, the picture and North Korea's statements provide no evidence that the object or test used a two-stage thermonuclear design. Moreover, the shape of the device in the picture and information in its statement do not appear to go beyond in content that which is available in the open literature. Absent other information, I believe it would be premature to assess that North Korea, which has had real struggles mastering technological targets, has reached such a difficult goal. I hope we can learn more about this test and North Korea's capabilities to build such devices. Perhaps, data and insights will come from defectors or from radioactive emissions from the test site, which are far likelier to have occurred in this test than earlier ones.

The test could have involved a boosted or a one-stage thermonuclear design, which are both easier to develop and build than a two-stage thermonuclear design. In this case, its miniaturization and weaponization for a missile is easier but also challenging. While I am skeptical that North Korea is able to successfully build such a design for delivery by an ICBM, achieving a weaponized one-stage or boosted weapon may not require more underground tests. It will likely require more above ground non-nuclear tests, but these can be done in military/nuclear research facilities that are very hard to detect or monitor remotely.

When can North Korea reach its goal of a miniaturized, high explosive yield warhead able to be successfully delivered to a target on an ICBM? This is difficult to precisely estimate but it will likely be within a few years, if testing continues unabated.

More tests?

More underground tests could refine North Korea's skills in designing more efficient fission weapons and fission boosted weapons (that use less plutonium or weapon-grade uranium per kiloton of explosion), and achieve designs with greater total explosive yields. North Korea could explore more optimized one-stage thermonuclear weapons and develop more tailored electromagnetic pulse (EMP) weapons. The bottom line is that if they test more, they will be able to develop more advanced weapons that can use less plutonium and weapon grade uranium (WGU), are more miniaturized for missiles, and can be more destructive if detonated.

With more tests, North Korea could succeed in building two-stage nuclear weapons. There are sound reasons to do so. Two stage weapons have advantages over boosted and one stage thermonuclear devices, namely (1) their explosive yield can be much higher (into megatons) than boosted or one stage designs which tend to be limited to several hundred kilotons, (2) their requirements for fissile material are less than one stage designs, and (3) their elongated shape (with a smaller fission explosive) can potentially fit more easily into missile reentry vehicles than one stage designs which tend to increase in diameter as the explosive yield increases. A two-stage design is simply more threatening than a boosted or one-stage design. But they are more complicated to develop than one-stage weapons. I believe that North Korea needs more tests and time to develop a miniaturized two stage thermonuclear weapon but it is motivated to do so.

North Korea's Nuclear Weapons Capabilities

The last several years have witnessed a dramatic and overt build-up in North Korea's nuclear weapons capabilities. The main activities that are known publicly include:

- Six underground nuclear tests in 2006, 2009, 2013, 2016, and 2017;
- Restart and refurbishment of the small 5 megawatt-electric (MWe) reactor at Yongbyon after a several-year halt;
- Revelation of a centrifuge plant at Yongbyon in 2010 and subsequent doubling of its floor size a few years later;
- Separation of several kg of plutonium in 2009 and again in 2016 from the 5 MWe reactor at the Radiochemical Laboratory at Yongbyon;
- On-going construction of an experimental light water reactor (ELWR) at Yongbyon (type of reactor is uncertain);
- Construction by a nuclear organization of a new graphite production facility. Graphite is a moderator in a type of reactor that is an excellent plutonium producer;
- Construction of facilities to make thermonuclear materials, including a lithium 6 enrichment plant and likely an Isotope Production Facility able to separate tritium;

- Modernization and construction of many buildings at Yongbyon, including likely one able to manufacture fuel for the ELWR and others to support reactor and centrifuge operations;
- Refurbishing of uranium mines and mills; and
- A robust program to develop, manufacture, and test ballistic missiles of various ranges.

In addition to known sites, North Korea has likely developed an array of secret facilities and activities. This unknown part of North Korea's nuclear weapons complex includes:

- The strong possibility of an older gas centrifuge plant that has made weapon-grade uranium for up to a decade
- Unknown sites to research, develop, and manufacture nuclear weapons and their components;
- Sites associated with nuclear weapon component testing, including full-scale cold-testing that complement underground nuclear testing at its Punggye-ri underground test site;
- Possible integration facilities that could mate a nuclear warhead to a ballistic missile; and
- Nuclear warhead storage capabilities.

All of these activities have been supported by extensive, often illegal, overseas procurements of equipment, material, and technology.

Estimated Number of Nuclear Weapons

North Korea has developed successfully the means to produce both plutonium and weapon-grade uranium for nuclear weapons. The size of its stocks of these materials provides a rough guide to the number of nuclear weapons North Korea has built.

Its stock of plutonium appears limited and all of it appears to have been produced in the small aging 5 MWe reactor at Yongbyon. It has a gas centrifuge plant at Yongbyon able to produce weapon-grade uranium. A substantial amount of weapon-grade uranium could also have been produced at unknown sites. Many assess that North Korea has another gas centrifuge plant at an unknown location that may have been producing weapon-grade uranium since about 2005 or 2006.

My Institute's median estimates of the size of North Korea's plutonium and weapon-grade uranium stocks through 2016 are:¹

- 33 kilograms of separated plutonium; and
- 175-645 kilograms of weapon-grade uranium, where 175 kilograms corresponds to a median estimate for the case of one centrifuge plant and 645 kilograms corresponds to the median estimate for the case of two centrifuge plants.

¹ David Albright, *North Korea's Nuclear Capabilities: A Fresh Look*, Institute for Science and International Security, August 9, 2017, <http://isis-online.org/isis-reports/detail/north-koreas-nuclear-capabilities-a-fresh-look-power-point-slides/>

Through 2016 (before the latest underground test), my Institute estimated that North Korea had about 13 to 30 nuclear weapons.² These values reflect the utilization of 70 percent of the available, estimated stocks of plutonium and weapon-grade uranium. This assumption means that thirty percent of North Korea's total stocks of plutonium and weapon-grade uranium are assessed as in production pipelines, lost during processing, or held in a reserve. The limits of 13 and 30 correspond to the median values for the cases of one or two centrifuge plants and each weapon contains either plutonium or weapon-grade uranium.

These estimates suggest that North Korea has a substantial number of nuclear weapons and add weight to assessments that North Korea is competent at using plutonium and/or weapon-grade uranium in nuclear weapons.

North Korea is currently expanding its nuclear weapons at an estimated rate of about 3-5 weapons per year. Again, the lower bound corresponds to one centrifuge plant and the upper bound corresponds to two centrifuge plants.

Through 2020, North Korea is assessed as having enough plutonium and weapon-grade uranium for about 25-50 (rounded) nuclear weapons. A worst case, involving the operation of the Experimental Light Water Reactor, is that it would have enough plutonium and weapon-grade uranium for up to 60 nuclear weapons by the end of 2020.

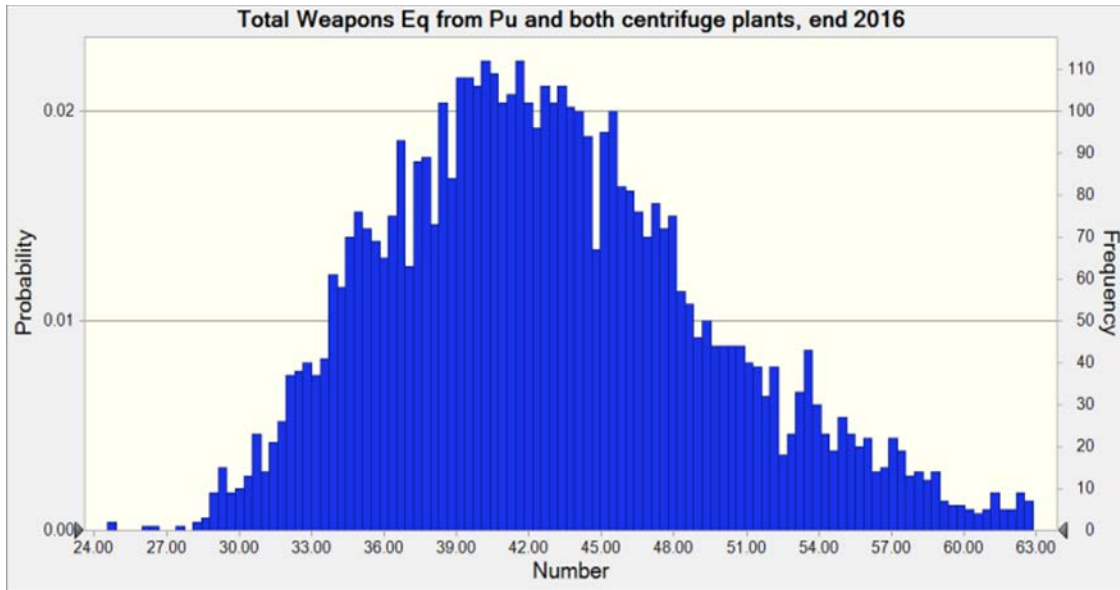
A Closer Look at the Upper bound: Two Centrifuge Plants

The upper bound of the estimate of the number of nuclear weapons through 2016 includes the production of weapon-grade uranium at a second, unknown enrichment plant. Based on discussions with U.S. officials, their estimates of nuclear weapons capabilities assume that this second enrichment plant exists and has contributed significantly to North Korea's stock of weapon-grade uranium. Although I am less sure, it is useful to focus on the case of two centrifuge plants producing weapon-grade uranium.

The lower and upper bound of the Institute's range above represent the medians of frequency distributions of estimates of the number of nuclear weapons, which differ mainly on whether North Korea has one or two centrifuge plants. Each frequency distribution is calculated by considering several variables, each of which is a range of values. These variables include the total number of centrifuges, the efficiency of the centrifuges, the length of operation, and the amount of plutonium or weapon grade uranium per weapon. All of these variables are uncertain, because of North Korea's efforts to keep its nuclear programs secret.

The following frequency distribution translates the total amount of plutonium and weapon-grade uranium into an equivalent number of nuclear weapons. In the chart, this value is abbreviated as the total number of nuclear weapons equivalent by "Eq."

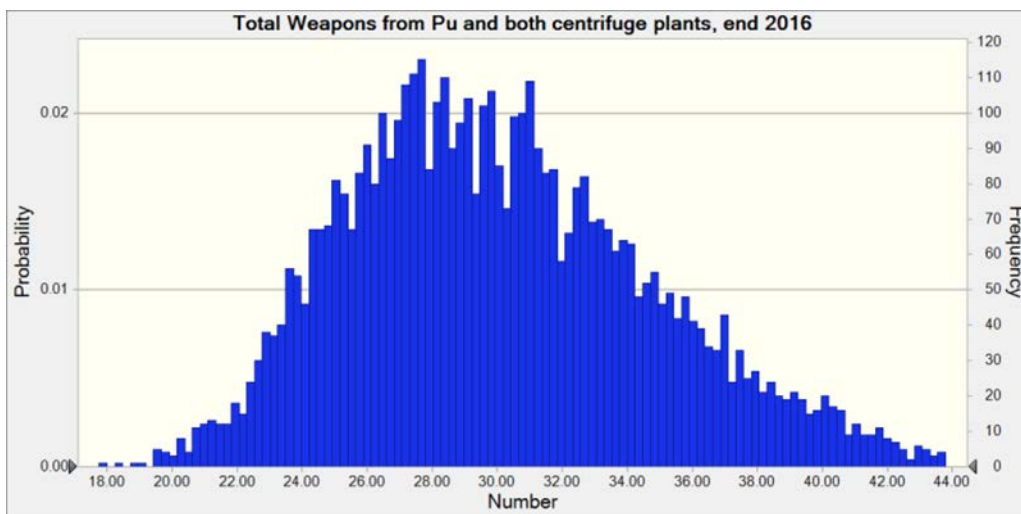
² Ibid.



The median of this slightly skewed distribution is about 42 weapons equivalent, with a standard deviation of 7 weapons equivalent. The full range is 25 to 75 weapons' equivalent.

However, as discussed above, the actual number of nuclear weapons would be expected to be fewer in number than given by the above nuclear weapons equivalent values. A fraction of the plutonium or WGU would be tied up in the manufacturing complex that makes nuclear weapons components or would be lost during such processing. Some of this material would be expected to be held in a reserve for underground nuclear testing or new types of weapons. In these estimates, it is assumed that only 70 percent of the total amount of plutonium or WGU is used in nuclear weapons.

Accounting for this reduction, the distribution of the estimated number of weapons made from plutonium or weapon grade uranium from two centrifuge plants at the end of 2016 is:



The median of this slightly skewed distribution is 30 nuclear weapons, with a standard deviation of 5 weapons. The full range is 18-53 weapons. The range defined from the 5th and 95th percentiles of this distribution is 23 to 39 nuclear weapons. The latter range of the number of weapons North Korea may possess is a more reasonable representation in the case of two centrifuge plants making weapon-grade uranium. However, I would stress that in our analysis this range represents a worst case.

One implication of this analysis is that a recent report that North Korea has up to 60 nuclear weapons represents a worst case. Alternatively, it is unlikely that North Korea has such a large number of weapons.

Thermonuclear Materials

For several years, evidence has accumulated that North Korea has been producing or procuring materials needed to make thermonuclear weapons, which has added credibility to North Korea's claims that it has been pursuing boosted or thermonuclear nuclear weapons. We assess that North Korea has established a domestic capability to make lithium 6, which is a key material for thermonuclear weapons whether in one or two stage thermonuclear designs (see also below). It is also the material irradiated in a reactor to produce tritium, which can be used in boosted or one stage thermonuclear designs. North Korea has expressed interest in deuterium, another key thermonuclear material. It has also constructed a new Isotope Separation plant at Yongbyon that could separate tritium produced in the 5 MWe reactor or in a small research reactor at Yongbyon, called the IRT reactor.

Types of Nuclear Weapons (warhead and delivery system)

North Korea is likely developing a range of nuclear warheads or bombs that can be fitted to delivery systems. However, there is little public information about the warheads or bombs North Korea has built or is developing. Based on delivery systems, North Korea may have:

- **Aircraft dropped bombs:** unknown if bomb designs exist but likely able to design
- **Nodong missile:** miniaturized, plutonium-based warhead likely; unknown if could build miniaturized fission-only composite core design (with both plutonium and WGU) but increasingly possible
- **Medium range missile,** land-based, warhead unknown
- **Intermediate range missile,** land-based, warhead unknown
- **ICBM,** land based, warhead unknown
- **Sea-launched missile,** medium range, warhead unknown
- **Tactical nuclear weapons,** such as backpack bombs and land mines; speculative if exist or planned

These delivery systems would likely entail different nuclear weapons designs and combinations of plutonium and weapon-grade uranium. A thermonuclear warhead is probably being developed for some of these systems.

Observations and Findings about North Korea's Nuclear Weapons Capabilities

- North Korea appears able to produce considerably more weapon-grade uranium than plutonium, providing a pathway to a much greater number of nuclear weapons.
- North Korea appears to have a family of relatively reliable, miniaturized fission weapons with the destructive force rivaling the size of the Hiroshima blast that can use plutonium or weapon-grade uranium and fit on a number of ballistic missiles.
- Miniaturization is assessed as being done for the Nodong missile for a plutonium-only warhead. North Korea could use similar warheads on its longer-range missiles, although it would need to ensure that they can withstand the harsher environment experienced by these longer range missiles, particularly an ICBM. Moreover, it may experience problems in miniaturization and achieving sufficient warhead ruggedness as it seeks to use composite cores of plutonium and weapon grade uranium or thermonuclear materials. As a result, nuclear warhead miniaturization efforts likely continue.
- Other weaponization issues probably continue to be under development, i.e. reliability, safety, and security of nuclear weapons.
- North Korea can achieve explosive yields, likely using crude thermonuclear or boosted designs, that can destroy modern cities. With time, likely within a few years, it will have a reliable capability to deliver and explode such weapons over targets.
- North Korea will continue to depend on importing key goods for its nuclear programs from suppliers.
- North Korea could proliferate its capabilities to other nations. Although this aspect of the problem is not discussed here, North Korea's nuclear proliferation to other countries remains a fundamental concern.

Foreign Procurements by North Korea's Nuclear Programs

The North Korean government directs highly organized and centralized illicit trade efforts to outfit its nuclear, missile, and military programs. The government also uses North Korean government officials stationed at embassies to conduct illicit procurement related business and it recruits private companies to obtain goods. North Korea has established entities abroad under its control that seek goods. It also uses North Korean expatriates who own private companies located abroad. In the past, North Korean government entities cooperated closely with Pakistan, obtaining critical sensitive gas centrifuge assistance.

North Korea has depended on illegal or questionable procurements for decades for its nuclear programs. In particular, it has sought European, Japanese, and U.S. goods for its nuclear programs. When it could no longer base its operations in Europe in the early 2000s, it shifted its operations to China where many procurement operations for its nuclear program have been centered since then. Operating in China and Hong Kong, it has acquired a wide range of goods from Chinese companies and middlemen, as well as from U.S., Japanese, and European subsidiaries, which have been deceived into thinking they were selling to Chinese end users. North Korean entities often contract with private Chinese and Hong Kong trading companies and sometimes manufacturing companies to acquire these goods, either from Chinese suppliers or subsidiaries of Western or Japanese suppliers in China. Although China is improving its export

control laws, Beijing has not done an adequate job of enforcing its laws and sanctions against illegal exports and retransfers to North Korea.

The following illustrates the range and types of goods North Korea seeks abroad and the important role these goods play in the development and success of a range of North Korean nuclear programs. Many of these procurements were detectable and could have been stopped. One example also focuses on North Korean schemes to bypass financial controls and sanctions that led to a U.S. asset freeze.

Procurements for North Korea's Centrifuge Program

The operation and expansion of North Korea's gas centrifuge program has depended on importing many goods and technologies from abroad. The annex contains a list of goods North Korea has imported for its centrifuge program during the last fifteen years. This list does not include the substantial centrifuge assistance North Korea received from Pakistan in the late 1990s and early 2000s.

Evidence supports that North Korea is still importing a variety of goods and technologies for its gas centrifuge program, while benefiting from earlier procurements obtained from abroad. North Korea can make key centrifuge components domestically and would be expected to be seeking independence from foreign supply. However, there is a wide range of materials and equipment that North Korea must import in order to produce these components and then make and operate its centrifuge plants.

Procurements for North Korea's 5-Megawatt Electric Reactor at Yongbyon

During the last several years, North Korea procured goods for its 5 MWe reactor and spent considerable funds on this endeavor. The intention appears to be the restoration and upgrading of the aged reactor. Many of these goods are neither high-tech nor certified for nuclear use. North Korea seeks them from abroad for various reasons, including finding them more affordable than producing them domestically or unable to manufacture them with sufficient reliability. In China, it procured carbon dioxide blowers for the primary cooling system, a Japanese emergency generator, and Sulzers water pumps for the secondary cooling system. North Korea also procured a relatively rare aluminum-magnesium powder for making cladding of fuel for this reactor. The supplier was in Britain but was apparently unaware of the diversion from China to North Korea.

Procurements for a Lithium-6 Enrichment Plant³

As discussed above, a critical thermonuclear material is lithium 6. Utilizing foreign procurements from China, North Korea is assessed as having built a lithium 6 enrichment plant at the Hungnam Fertilizer Complex, near Hamhung on North Korea's east coast. This site is involved in ammonia processing, fertilizer production, and other chemical processing. Key

³ David Albright, Sarah Burkhard, Mark Gorwitz, and Allison Lach, "North Korea's Lithium 6 Production for Nuclear Weapons," Institute for Science and International Security, March 17, 2017, <http://isis-online.org/isis-reports/detail/north-koreas-lithium-6-production-for-nuclear-weapons/10>

procured items included metric ton quantities of mercury and tens of kilograms of lithium hydroxide which are strong indicators of a lithium-6 enrichment plant. The order of mercury and lithium hydroxide was from a 2012 North Korean contract to arrange the purchase of a wide range of industrial and lab-scale equipment and materials abroad in China. Although the purpose of the contract was not included, the list of goods implies they are for a lithium 6 enrichment plant using mercury-based lithium exchange. The contract had handwritten notes stating that the goods were needed urgently and the procurements involved the Hamhung complex. Most of the procurements were for industrial-scale equipment.

Shenyang Machine Tools Company⁴

North Korea seeks advanced machine tools abroad, including from European suppliers. These machine tools are important in nuclear and ballistic missile programs. Headquartered in northeast China, Shenyang Machine Tools Company allegedly supplied sophisticated 6-axis machine tools to North Korea containing controlled subcomponents. The subcomponents were provided by a European company under the condition that they would not be re-exported. The company imports a range of subcomponents from major Western supplier nations. It sells its machine tools in China and globally, including in Europe and the United States. European government officials gathered evidence that at least two 6-axis machine tools, containing controlled, imported subcomponents, were exported to North Korea in about 2015 without authorization from the supplier country, a requirement of the original supply of the goods. Although Shenyang company officials have stated that the exports were inadvertent, other evidence suggests that the company did know about the end destination of the controlled goods being North Korea. The Chinese government refused to cooperate with a foreign criminal investigation to determine the actual situation, backing the company's claim that the exports were inadvertent or uncontrolled re-exports. As a result, legal options to investigate the company's exports are limited. However, my Institute recommends that this company should be considered a candidate for U.S. sanctions. In addition, the United States should take other measures to ensure that U.S. companies' and other suppliers' goods are not re-exported to North Korea, in part by obtaining verified assurances from Chinese companies. Moreover, China should require its companies to have internal control systems and hold top company officials liable for illegal exports originating within their companies.

Dandong Chengtai of China and Velmur Management and Transatlantic Partners (both Russian-owned) of Singapore

North Korea has used a range of methods to bypass financial sanctions and regulations on its nuclear, missile, and arms programs. On August 22, 2017, the Department of Justice announced two law suits against financial and nonproliferation sanctions busting rings in China and Singapore (the latter involving Russian-owned entities and individuals).⁵ The Trump

⁴ David Albright, "Shenyang Machine Tools Company," Institute for Science and International Security, April 13, 2017, <http://isis-online.org/isis-reports/detail/shenyang-machine-tools-company>

⁵ See: Andrea Stricker, "Case Study: United States Levies Civil Suits Against Chinese and Russian Entities for Helping North Korea Bust Financial and Nonproliferation Sanctions," Institute for Science and International Security, September 7, 2017, <http://isis-online.org/isis-reports/detail/case-study-united-states-levies-civil-suits-against-chinese-and-russian-ent>

administration also sanctioned the entities and individuals involved in the case. The law suits froze North Korean assets that touched U.S. correspondent banking accounts. The suits alleged that the rings are working to help North Korea buy or sell goods internationally and then launder the money for its nuclear, missile, and military programs. The first law suit against Dandong Chengtai, which was conducting prohibited coal trade and illicit financial transactions with North Korea, shows that enforcing the new UN resolution 2371 to prohibit coal trade with North Korea may temporarily restrict its ability to acquire needed dual-use goods for its nuclear, missile, and military programs. The Velmur/Transatlantic case involved Russians setting up front companies in Singapore in order to make prohibited financial transactions for North Korea for purchases of Russian gasoil. This case shows that North Korea's imports of gasoil (as well as oil) are vulnerable commodities that deserve UN sanctions.

Countries Violating UNSC resolutions on North Korea

As part of preparing this testimony, we decided to use a new tool we have developed to evaluate preliminarily 33 countries that the United Nation Security Council Panel of Experts on North Korea identified as violating UNSC resolutions on North Korea.⁶ Although this list is not complete, it appears to be fairly representative of the type of countries implicated in nefarious activities with North Korea. These countries show a tendency of cooperation with North Korea in its illicit procurement of goods for its nuclear or missile programs, as well as cooperation with North Korea in its attempts to evade sanctions. Common offenses include facilitating or initiating the re-flagging of ships, and the setting up of front companies and bank accounts. Some of the countries are involved in the import of banned North Korean goods, such as iron and ore. Others cooperated with North Korea militarily in areas of training, arms, and equipment. This includes North Korea's alleged export of surface-to-air missiles or related equipment to at least two African countries.⁷

Using what we have developed and titled the Peddling Peril Index (PPI), which measures the extent and effectiveness of a country's strategic export control systems, we considered the ranking of these 33 countries in terms of trade control legislation, proliferation financing, and overall ranking in the index.

The group of countries that deal with North Korea on illicit or sanctioned goods or services tend to have a relatively poor overall ranking on the PPI. The ones that have a higher ranking tend to have adequate export control legislation but poor enforcement or anti-proliferation financing practices.

On the issue of proliferation financing, half of all countries on the list rank in the bottom 30 percent of the 200 countries evaluated under this criterion. This means that many of these 33 countries do poorly on preventing proliferation financing.

Almost all of the countries that deal with North Korea on conventional arms or are involved in reflagging their vessels have no or poor export control legislation.

⁶ All reports can be found on the website of the United Nations Security Council Subsidiary Organs: https://www.un.org/sc/suborg/en/sanctions/1718/panel_experts/reports

⁷ Mozambique and Tanzania, see http://www.un.org/ga/search/view_doc.asp?symbol=S/2017/742

Many of the countries identified in this list experience a high degree of corruption. Notably, countries on the list with adequate export control legislation, which typically translates into less corruption, performed more poorly than their peers.

These results suggest that North Korea targets those countries with weak or nonexistent export and proliferation financing controls and suffer from on average more corruption than other countries. Although a range of remedies are needed to fix the poor performance of many of these countries on this list, the creation of punitive measures may be an effective means to accelerate more compliant behavior in the short term.

Thank you for inviting me to submit testimony.

Annex: North Korean Illicit, Foreign Procurements for Centrifuges (non-Pakistani supply)

North Korea has sought the following advanced goods from Western countries and via China for its gas centrifuge programs:

- **Materials:** Aluminum tubes (low strength for outer casings), ring magnets for use in a centrifuge upper bearing, epoxy resins used in assembling centrifuge parts (sold commercially as Araldite), raw materials and additive alloys;
- **Vacuum Equipment:** A range of equipment important to operating centrifuges individually or in cascades, such as vacuum pumps, valves, specialized uranium hexafluoride resistant oils. Also pressure transducers, which are used to measure the vacuum pressure in individual centrifuges and cascades;
- **Other Equipment:** Uranium hexafluoride cylinders, uranium hexafluoride flow meter, He leak detectors, and frequency converters or their subcomponents. Also computerized control equipment, including software and updates, used to run a plant composed of centrifuge cascades. (The equipment is the same as that acquired by Iran to control its centrifuges.)
- **Manufacturing Equipment:** Flow-forming machine usable to make centrifuge rotors. an electron beam welder for centrifuge assembly, equipment to make ring magnets. State-of-the-art computer numerically controlled (CNC) machines for making centrifuge parts, and measuring equipment;
- **Spare parts** for centrifuge-related equipment.