Introduction

It is a cliché to note the rapid increases in computing power that put more power in your celluar phone than existed in the Apollo Moon Lander. But that increase is a real one, a change that affects everything including how we study the spread of nuclear weapons.[1] To get a sense of how complete those changes are, think about something small – such as how people used to share vacation photographs.

Here is how people shared photographs in the 1980s. One had a single-purpose analog device called a camera. One used the camera to make a picture by exposing film to natural light. Each roll of film could record only 24 exposures and needed to be stored carefully. When one was out of exposures, the film was removed and hand-carried to a shop where another person used a chemical process to develop pictures from it.

A few days later, one returned to the shop to pick up the photos – to share the images, one needed to have remembered to order copies of the pictures. Then one of the copies could be placed in an envelope with a stamp, and a series of human beings employed by the US Postal Service would deliver it.

Having done all this, one had successfully shared a picture. But my the recipient couldn't share the picture with anyone else. Moreover, unless the one remembered to write vital information in ink on the back, after a few years the memory of who took the picture, when it was taken and where it was taken might vanish. Saving and sharing information was very labor intensive and therefore expensive.

Now consider a smart phone. It contains a camera, which records an instant digital image. A 16GB iPhone can hold more than 2,000 images, but chances are you use space for other things your phone can do like take high-resolution videos or record audio. The same device can access the internet, from anywhere in the world, to share still images, video or audio with everyone else in the world. One can email the image, upload it to Dropbox, or post it on Facebook, Twitter or Instagram, where other people can look at the pictures instantly using *their* smartphones and share them the same way with anyone else in the world. These images can be encoded with metadata about the time, location and even type of camera that took the picture, as well as where and when the user uploaded it. The cost of recording, saving and sharing data is asymptotically approaching zero.

What this means is that the declining cost of information is fundamentally changing how we live our lives. Human beings truly live on-line. And that means that sensitive national security information can be found there, and analyzed. What follows are three case studies that demonstrate how this change is altering how we study the spread of nucler weapons.

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[1] This concept is explored in more detail in Jeffrey Lewis, *A Nuclear Detective Story: How New Internet-Based Tools are Changing Nonproliferation*, Nuclear Threat Initiative, May 2, 2016. Available at: http://www.nti.org/newsroom/news/nuclear-detective-story-how-new-internet-based-tools-are-changing-nonproliferation/

North Korea's Missile Launchers

On April 15, 2012, North Korea paraded what appeared to be six road-mobile missiles, quickly identified in the media as KN-08 intercontinental ballistic missiles (ICBM), through Kim Il Sung Square in Pyongyang.[2]

Chinese bloggers almost identified the unusual vehicles as Chinese-manufactured transporter-erector-launchers (TELs) used by Beijing's strategic missile forces. Officials in Beijing, however, stated that China had only exported civilian-use chassis, which North Korea claimed would be used for forestry. China claimed that North Korea had imported the chassis and modified them by adding an erector mechanism to lift the missile into position for launch.

So what is the truth? Did China export a truck that North Korea modified?

The first step in answering a question like this is to determine where North Korea might have modified the trucks imported from China. In 2013, North Korea released a commemorative video entitled, *Kim Jong Il's Efforts to Defend the Country*, which was posted by a pro-North Korean group on YouTube. Although it is strange to think of North Korea using social media extensively, the country's state-run propaganda apparatus and affiliated groups in foreign countries make extensive use of such platforms to share and distribute the regime's propaganda internationally.

Kim Jong Il's Efforts to Defend the Country contains footage taken inside what appears to be North Korea's facility for completing assembly of missile launchers. Three clips lasting a few seconds show launchers for the Nodong missile and then launchers for the KN-08 ICBM. One of the KN-08 launchers was even still painted red, which is the color of the trucks in many Chinese marketing materials.

The shape of the building with the KN-08 launchers is quite distinct. Along one of the long sides of the building there is an unusual pattern of clerestory windows—high windows above eye level—as well as the cupola-like structure near the center of the building. Moreover, the windows run along only one of the long sides of the building, suggesting that it is either partially buried or has an adjoining structure on the opposite side. And the windows along the short side of the building are spaced in an irregular manner and make an identifiable pattern. In fact, the building is so unusual that it is possible to model the outside of the structure from the inside.

The Center for Nonproliferation studies digitally constructed the building interior on SketchUp, a free, widely-available 3D modeling program. This rendering revealed the structure's approximate dimensions, and based on the windows and roof, suggested that the two clips may have been filmed in *different* buildings.

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[2] This case study is drawn from: Jeffrey Lewis, Melissa Hanham and Amber Lee, "That Ain't My Truck: Where North Korea Assembled Its Chinese Transporter-Erector-Launchers," *38 North*, February 3, 2014. Available at: http://38north.org/2014/02/jlewis020314/.

Once we had models of the buildings, we began to search for them using the large amount of imagery freely available online from Google Earth and other platforms. Many defectors described the location of various North Korean defense industries, including the location of factories to make missile launchers. When we napped the locations, most clustered within a few kilometers of each other, creating a manageable search area.

Less than 5 km northwest of the Jonchon train station, lies a building that matches the model of the building created for the KN-08. The building has a single row of high, clerestory windows because the main building has an adjoining structure. The completely windowless opposite side appears to be flush with another hall. The windows at the eastern short end match very closely. The large cupola is revealed to be a curved, fan-like structure (consistent with the arc made by the tip of an erecting missile on a TEL inside). We purchased new satellite images, including a low-angle view that shows the windows running alongside the south of the building. They are not evenly spaced, presenting the opportunity to match the inside of the building with the outside. As it turns out, the two different roofs are actually from the same building. North Korea remodeled at the same time it negotiated for the export of the KN-08 chassis.[3]

Why did North Korea alter the roof? The original roof was too low to allow the KN-08 to full erect a missile. Our colleagues had built a model of the KN-08 TEL and missile using parade images and marketing materials for the truck. Combining the models of the building and the launcher demonstrates that the roof was remodeled to accommodate the KN-08 erector mechanism – strong evidence that North Korea modified the trucks on-site.

One final question remained. Although the new roof was large enough to accommodate the KN-08, the width of the building was barely enough for the long transporter vehicle. While we were initially baffled, a colleague was able to find the answer by posing the question on her Facebook account. When she asked how the truck might be moved around within the building, her cousin noted that factories that make large vehicles move them around on casters. We were able to find footage on YouTube showing large vehicles being assembled on casters

Iran's Matiran Facility

On February 24, 2015, an Iranian-dissident revealed the location of what it claimed was an underground centrifuge facility in the suburbs of Tehran. The announcement was, evidently, intended to derail ongoing negotiations toward a diplomatic settlement over Tehran's nuclear program.[4] There were a number of questions that arose almost immediately about the credibility of the report.

The site shown in images by the dissident group was easy enough to find – Matiran is a real

[3] There is a second building nearby that has very similar characteristics that we call Site B. This site is described in more detail in the full report.

[4] This section is drawn from: Jeffrey Lewis, "That Secret Iranian 'Nuclear Facility' You Just Found? Not So Much," *Foreign Policy*, March 5, 2015. Available at: http://foreignpolicy.com/2015/03/03/that-secret-iranian-nuclear-facility-you-just-found-not-so-much/

company in Iran. It makes passports and other official documents that must be secure and difficult to counterfeit. The location of the particular facility in question is not a secret.

The dissident group indicated that the underground plant had been constructed over the course of 2004-2008. But construction crews normally build large underground facilities using a method known as cut-and-cover. As the name suggests, one digs a large hole ("cut"), constructs the building inside the hole, then "covers" it with earth. This is how Iran constructed the underground centrifuge facility at Natanz. (It is also possible to tunnel horizontally into a mountain, as Iran did near Qom, but the Matiran site is flat.)

There are many satellite images of the Matiran site between 2004 and 2008 when the facility was allegedly constructed. None show any evidence of cut-and-cover construction. None show any construction to speak of.[5] Moreover, satellites images do not show either structures for ventilation or the electrical substation that one would expect to see at such a site. While these structures can be camouflaged, it hard to camouflage something while it is being built. While imagery analysis of Matiran did not conclusively disprove the allegations, it raised serious doubts about the reliability of the information.

Another problem arose relating to a door that the group alleged was installed at the site. Critics quickly noted that the image was taken from a website of a company that manufactured safes and vault doors. The image released by the dissidents had been cropped. The full image, however, showed the door was sitting in an above ground warehouse.

Digital photographs are encoded with what is called metadata – data about the photograph that can include the type of camera, any software used to save the file, the date and time it was taken, and in some cases the location of the camera. Although there was only a limited amount of metadata in the images on the website of the company in question, the metadata was consistent across the images – something that suggested the image of the door was nothing more than part of a larger set of images taken to advertise GMP's products. Using the commercial satellite images, the Center for Nonproliferation Studies was able to locate the warehouse where the door was located. The image does not show a door either installed at the Matiran facility or waiting to be installed there.

But the door raised another, deeper problem. Enriched uranium does not give off a radiation signature that would require such a door. At CNS, our staff have modeled a large number of enrichment facilities, including the Pilot Fuel Enrichment Plant and Fuel Enrichment Plant in Iran, and North Korea's enrichment plant at the Yongbyon Nuclear Research Center. As images of the facilities in Iran demonstrate, the doors are are no different from those one might find in an office building or warehouse.

In fact, the facility described by the dissident group differs in important ways from real facilities that we have modeled. The layout of centrifuge facilities is not an accident; it reflects the function of the site. Enrichment facilities are not simply rows and rows of centrifuges. There is

[5] See Phil Baxter, "The Lavizan-3 Site," *Arms Control Wonk.com*, March 3, 2015. Available at: http://www.armscontrolwonk.com/archive/207579/lavizan-3/

an enormous amount of space dedicated to control systems and equipment such as autoclaves that must be located around the centrifuges to allow the feeding and withdrawal of uranium hexafluoride.

A simple comparison of known centrifuge facilities to the one described by the dissidents shows that the story is not very plausible. The tunnels do not appear suitable even for a small enrichment facility, such as the North Korean gas centrifuge enrichment plant at Yongbyon, or even an R&D facility such as the Pilot Fuel Enrichment Plant at Natanz, in Iran.

Of course, these are good reasons to doubt the credibility of the report. But what would be best would be to find someone who was actually in the facility. In fact, we were able to find a a GPS trace created by a European who visited the site in February 2013. The person participates in a project called "Open Street Map" which is an open-source effort to create the equivalent of Google Maps. The user traveled from a hotel in Tehran to the Matiran facility in question and uploaded the GPS trace of his route to Open Street Map. (He has since taken it down.) Despite claims by NCRI that the site is located within a "restricted military zone," he took a car right into the site. Since the journey is time-stamped, we can tell he didn't not pass through checkpoints

My colleague Paul-Anton Krüger, who writes for the German daily Süddeutsche Zeitung, and I contacted this person and were able to confirm his identity. Iran makes identification cards at the site. It also has a steady stream of foreign visitors. None of his colleagues saw anything out of the ordinary. In addition to foreign firms working with Matiran, at least two international delegations have also visited the facility. Iran organized an October 2011 site visit by a delegation of National Civil Registration Organizations as part of a conference held in Tehran. Iran organized a second site visit, in April 2013, as part of a similar meeting.

North Korea's Submarine Launched Ballistic Missile

One of the major questions is how we can use propaganda, when it is evidently intended to deceive us. North Korea's release of footage of a test of a missile from a submarine, however, suggests that manipulating digital images is far from easy.

North Korea released footage of January 8, 2016 to show what the North Koreans claim was a successful test of a submarine-launched ballistic missile. There had previously been press reports that the DPRK had conducted a failed ejection test in December, followed by a successful test in December. "No additional details of the test could be learned," one reporter wrote about the December test, "including whether the missile's engine ignited after the ejection or whether the missile took flight."

Yet those details were readily available in the video footage released by North Korea, which demonstrated that the missile exploded.[6]

North Korea released video of the launch. The video itself was edited in a way that made it difficult for a casual viewer to scrutinize the footage. There are scenes of a missile popping up out of the ocean and then igniting, interspersed with images of Kim Jong Un aboard a boat, smiling and gesticulating.

First, we were able to locate the launch site, using the rugged terrain along the coastline. The launch occurred near a shipyard at Sinpo, which is where North Korea's submarine-launched ballistic missile program is based.

The Center for Nonproliferation Studies created a frame-by-frame dissection of the video, which yielded further information. Although North Korea had manipulated the footage to give the appearance of several launches or shots from multiple cameras, it was clear that the clips all showed the *same launch* of a single missile.

Once the three clips of the same launch were played side by side, it became obvious that one clip lasted a few frames longer than the others. These extra frames contained tell-tale evidence of an explosion including ejecta and what appeared to be the disintegration of the missile engine in a ball of fire.

Finally, we compared the footage to Soviet-era footage of the launch of an R-27 – the missile on which the KN-11. When the two videos are run side-by-side, the unusual behavior of the North Korean missile is easy to see. It exploded.

What is most notable about this case is that this information is available in a propaganda video deliberately manipulated to present the launch as a success. Although states may strive to alter evidence, it is not at all clear that such alterations can be successful. And since we live in such a data-ubiquitous society, the expectations that propaganda must meet to achieve its purposes are much higher than in the past.

Implications

As the cost of collecting, storing and sharing information decreases, we are increasingly integrating the use of data in our everyday lives. Data is now ubiquitous, in part because it is so inexpensive.

[6] This section is drawn from a video analysis presented in: Catherine Dill, "Video Analysis Of DPRK SLBM Footage" January 16, 2016. Available at: http://www.armscontrolwonk.com/archive/1200759/video-analysis-of-dprk-slbm-footage/

Just as technology companies like Google increasingly see the value of their service in terms of the data it collects about users, analysts who study international relations should see the opportunities for academic research in new sources of data that are freely available.

There is, of course, something of an arms race underway. The same digital tools that allow us to scrutinize images can also be used to alter them. States will necessarily respond to data ubiquity by changing security procedures. South Korea, for instance, recently and belatedly banned cell phone from sensitive sites. At the same time, the ubiquity of data probably favors openness. When there are so many ways for information to escape, the challenge of keeping secrets becomes increasingly difficult.

Moreover, the expectations for public disclosure are also changing. North Korea is not releasing images of its nuclear and missile programs to aid analysts, it is doing so because Pyongyang feels compelled to include visual components to its propaganda. States may choose to simply not disclose images at all, but this too comes at a cost to propaganda and deterrence. Human beings live online, which means that opting out of the information revolution is unlikely to succeed. Far more likely is that states will come to accept greater levels of transparency no matter how unwelcome.

This is not to say that this new environment is a purely positive development. Just as we can assess the state of North Korean or Iranian nuclear and missile programs, we can also discover information about US or French nuclear programs. These new techniques may pose a challenge for the survivability of nuclear deterrent systems or aid terrorists in planning attacks. But whether the ubiquity of data is, on the whole, a positive or negative development is less important than the realization that it is an inevitable one, driven by the falling cost of collecting, storing and sharing information. It is is inexorably changing all aspects of our lives, from how we study the spread of nuclear weapons to how we share vacation photographs.