The Uses and Challenges of Satellite Imagery in Researching North Korea

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Abstract
The use of commercial satellite imagery has become a common practice when assessing developments in North Korea. Given limited access to the country, especially its more politically or militarily sensitive areas, imagery has provided an important and, in some cases, the only look at facilities that help the international community gain a better understanding of what is happening on the ground. However, although satellite imagery is increasingly used to research and monitor North Korea, caveats about how much can be learned from it alone are significant. Limits to imagery resolution and frequency of viewing can create distorted narratives if considered in isolation. Instead, the imagery needs to be paired other sources of data that help situate it in the appropriate context of the times. Moreover, North Korea's ability to adapt to a highly monitored environment also emphasizes the constant need to factor in the potential for camouflage, concealment, and deception practices when viewing any image. Failing to take these factors into consideration can lead to misleading or over-extrapolated conclusions. Because images increase the persuasive power of the analysis, and news and social media cycles are unrelenting, the burden is heavy on researchers to do their due diligence, consider the ethical implications of their work, and conduct responsible analysis. Despite these limitations, satellite imagery provides a source of hard data to review and debate, as well as a window into areas of North Korea where there is generally no visibility.

Introduction

Commercial satellite imagery is an important source of data about North Korea, providing windows into a country where access is limited even under the best of circumstances. When combined with other data sources, it can help enhance understanding of current and long-term developments on the ground.

This paper reviews both the growing use of satellite imagery in studies about North Korea and the numerous ways it is facilitating data-driven analysis. It discusses the challenges of working with satellite imagery and the need for careful, conscientious analysis to provide responsible and meaningful contributions to the field.

Background

Although high-resolution commercial satellite imagery has been available to the public since 1999, its usage in North Korea studies did not gain wide traction until around 2012.[1] Prior to that, studies that featured satellite imagery were limited, mainly focused on sites central to North Korea's nuclear program such as the Yongbyon Nuclear Scientific Research Center and Punggye-ri Nuclear Test Site.

The limited usage was due in part to the limited availability of imagery posted to public catalogs as well as the prohibitive cost of licensing this imagery on a regular basis. Satellite imagery companies collect enormous quantities of images, but not all of it is pushed into their public catalogs. The decision may be based on technical or political considerations, or simply corporate preferences and priorities, but the choice of what is made public is at the companies' discretion.[2]

Moreover, the cost associated with licensing commercial satellite imagery is not insignificant. Pricing is based on various criteria such as area size, acquisition date, resolution, and format. For optical imagery, even a minimum order of 25 square kilometers can range in price from $600 to 700 to upward $1,500 per image depending on a combination of these factors. Synthetic-aperture radar (SAR) imagery can run $5,000 to 10,000 per image. In many cases, only low-resolution previews of the imagery are provided to the customer before purchase, making it also difficult to determine the true value of an image to one's goals in advance.

As satellite technologies have advanced and the industry has expanded, satellite imagery has become more accessible to the general public with the emergence of free or lower cost options, although many of these options are of lower resolution. Additionally, as public interest in North Korea has grown, satellite companies have responded accordingly, collecting imagery of key sites in North Korea at more frequent intervals, making efforts to broaden the areas of the country captured, and pushing more imagery into their public catalogs.

The Landscape of Satellite Imagery Studies of North Korea

Several types of satellite imagery are available to the general public, providing researchers with a wide range of working options.[3] For a country like North Korea, where access is limited especially to more sensitive areas for either political or security reasons, satellite imagery has provided ways around those restrictions. Researchers have used various types of satellite imagery in a variety of ways to increase understanding of North Korea today.

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[1] At least 1-meter resolution or better one.

[2] Technical reasons could be a variety of factors such as problems with resolution or excess cloud cover. In the Korean context, for instance, the summer monsoon season is an especially difficult time to acquire cloud-free optical imagery.

[3] Some of the more common types that have been used in studies about North Korea include optical imagery, images that capture the optical part of the spectrum and are displayed in either natural color, as viewed by human eyes, or in false-color infrared, which aid the detection of features not visible otherwise, such as vegetation health. Thermal images depict the distribution of temperature. SAR images are created using radio waves rather than utilizing light from the sun. This is especially useful for capturing images at night and imaging through clouds and smoke. Nighttime optical imagery detects lighting on the ground, such as from cities and towns.

North Korea at a Glance

First, satellite imagery can be useful in defining larger-scale features of North Korean sites of interest. Characterizing these general features can help improve understanding of the country's geospatial layout and development, making it easier to identify undeveloped versus urban areas, sharp differences in elevations such as mountains and valleys, shallow areas along the seacoasts, and sites such as airports, ports, bridges, railways and stations, and more.[4]

Understanding the common features of North Korea's marketplaces, for instance, which are characterized by a cluster of long, narrow, blue-roofed, single-story buildings, has led to a number of studies about how marketplaces have developed throughout the country since the famine era.[5] The consistency in structure and dimensions of similar buildings across the country, paired with pictures from inside the one or more of the markets, helps researchers estimate the approximate number of vendor stalls within each market complex. Combined with information about how much it costs a vendor to rent a market stall, the assessment of how many markets exist around the country and approximately how many stalls are contained in those markets form a basis for estimating the "taxes" or "rents" the regime may earn from market activity. Because North Korea does not publish hard numbers about its economic performance, satellite imagery can provide unique insights into an otherwise opaque aspect of the country's economy.

WMD

One of the most prominent ways satellite imagery has been used in North Korea studies is to monitor activities and developments at facilities associated with North Korea's weapons of mass destruction (WMD) programs. Despite the limits to what can be learned from only aerial views, imagery has helped improve understanding of how Pyongyang's nuclear weapons programs have developed over time based on infrastructure and activity in and around these sites. Assessing activity around key sites provides indicators as to what parts of the program are active or suspended and when expansions or modifications are made to related infrastructure, indicating program priorities and practices.

At the Yongbyon Nuclear Scientific Research Center, for instance, understanding when and how long the 5 MWe reactor may have been operating is an important factor when estimating how North Korea's fissile material stocks may have evolved over time. When trying to assess the status of the reactor, a few visual indicators are sought. These include steam emitting from the building housing the reactor's steam turbines and electric generators, which indicates that the reactor is

[4] Matthew G. McKinzie and Thomas B. Cochran, "Conducting Research on North Korea using Commercial Satellite Imagery, Map and Other Geographic Data," paper presented to the 54th Pugwash Conference on Science and World Affairs, October 4-9, 2004. https://fas.org/nuke/cochran/nuc_04100401a_238.pdf

[5] See, for instance, Benjamin Katzeff Silberstein, "Growth and Geography of Markets in North Korea: New Evidence from Satellite Imagery," US-Korea Institute at the Johns Hopkins School of Advanced International Studies, October 2015. https://www.jstor.org/stable/pdf/resrep11150.1.pdf; Victor Cha and Lisa Collins, "The Markets: Private Economy and Capitalism in North Korea?" Beyond Parallel, August 26, 2018. https://beyondparallel.csis.org/markets-private-economy-capitalism-north-korea/

likely either nearing or in operation.[6] It is also common to see effluent expelled from the secondary cooling system's discharge pipeline when the reactor is running, though this is not the only time this indicator would be observed. Water discharge could also signal that the North Koreans were testing the cooling loop, performing maintenance on the cooling system, or simply attempting to deceive for political reasons. Trained imagery analysts therefore look for a combination of indicators when trying to make these kinds of determinations.

Although imagery is useful in trying to monitor and assess the operations of key facilities, the kinds of conclusions that can be drawn based on imagery alone are subject to caveat. For instance, gaps in commercially available coverage are often large, making it difficult to assess the consistency of activity over time. In the case of the 5 MWe reactor, signatures such as steam generation and warm water discharge indicate that the reactor was probably running the day the image was captured. Without frequent coverage, however, determining whether the reactor ran constantly or only intermittently is difficult. It also does not convey the level of reactor operations—at full or partial capacity. These factors of operation consistency and output level would substantially affect production estimates.

Imagery can also be useful as a verification tool when facilities are not in use. For instance, after the exploding of test tunnel entrances and support infrastructure at the Punggye-ri Nuclear Test Site in May 2018, questions loomed as to whether North Korea would try to reactivate the facility, especially given that imagery showed the Command Center for the complex remained intact. Monitoring of this site since then has revealed no efforts to re-excavate the tunnel entrances or rebuild the support buildings and infrastructure, despite what appears to be continued patrolling and maintenance of the area. Without access to the test site to verify its dismantlement, satellite imagery provides a way to at least monitor for attempts to restore its previous capabilities.

Because US and international experts and officials are rarely granted access to North Korea's WMD related facilities, especially without some kind of nuclear agreement in place, satellite imagery is one of the only open source ways to gain insights into the country's ongoing WMD program developments.

Human Rights and Human Security

Satellite imagery can be extremely useful in efforts to monitor and assess developments in North Korea related to human rights and human security. For instance, when it comes to North Korea's political prison camps, the Committee for Human Rights in North Korea has published a series of reports that combine North Korean defector testimony and satellite imagery to characterize the common physical features of prison camps as well as monitor activity over time.[7] In this context, imagery can help show patterns of life to see whether the camps are still active; whether and when facilities within the complex are renovated, expanded, or closed; or even evidence of forced labor at mines located within the secure grounds. Such imagery-based studies can provide documentary

[6] See, for instance, "Nick Hansen and Jeffrey Lewis, "North Korea Restarting Its 5 MW Reactor," *38 North*, September 11, 2013. https://www.38north.org/2013/09/yongbyon091113. Before the cooling tower was demolished in 2008, steam emissions from the cooling tower were another indicator of reactor operations.
[7] See the Committee on Human Rights in North Korea's publications listing for a full list of reports on North Korea's prison camps and political prisoner system (https://www.hrnk.org/publications/hrnk-publications.php).

evidence in attempts to hold the government accountable for violations of international human rights laws and norms.

Remote sensing data is also commonly used to monitor such things as agricultural production in efforts to assess North Korea's human security. In a country where malnutrition is persistent and domestic food production is critical to the well-being of the people, understanding how weather, such as floods or drought, affects crop health and potential harvestability is essential. One such report in 2017 used satellite imagery to assess the effects of droughts on that year's harvests. It compared the normalized difference vegetation index measurements, based on thermal imagery, with comparable periods in the previous years, assuming similar crop management practices were followed in both periods with regard to growing season conditions.[8] A similar study in 2020 by Crop Monitor (a GEOGLAM initiative), looked at the impact of the summer typhoons on primary rice producing areas, identifying which agricultural areas experienced the worst flooding effects and how that would likely impact harvests.[9]

These kinds of studies of North Korea's agricultural situation help better assess the country's humanitarian needs. Data-driven analysis like this is important when access to the country's critical areas is limited or nonexistent and trust in the government's official reporting of the situation is minimal.

Economic Infrastructure and Activities

Satellite imagery is also useful in looking for regional and nationwide development patterns and trends. For instance, studies have examined the development of hydropower dams and plants in North Korea. One noted a move away from the large signature hydropower plant projects of the Kim Jong Il era and toward more durable small to medium-size tiered plants in the north central and northwest provinces of the country, dams and reservoirs adjacent to their associated power plants.[10] Although some of these developments were mentioned in the North Korean press, the region by region analysis helped corroborate and illustrate the trend over time. In a follow-on study of the hydropower plants in the northeast provinces, especially Ryanggang Province, satellite imagery showed evidence of a unique pattern of development less discussed in North Korean media, water supply to these plants fed through a complex series of large reservoirs and vast integrated system of waterway tunnels.[11]

In addition to domestic economic activity, satellite imagery is now commonly used to help identify North Korea's illegal and sanctions-violating activities. For instance, a recent innovative study in *Science Advances* used various kinds of satellite imagery to assess the scale of illegal fishing by

[8] Andy Dinville, "Assessing Agricultural Conditions in North Korea: A Satellite Imagery Case Study," *38 North*, January 5, 2017, https://www.38north.org/2017/01/adinville010517/.
[9] Group of Earth Observations Global Agricultural Monitoring (GEOGLAM) Initiative. "Heavy rains and flooding in August affect primary rice producing areas in the Democratic People's Republic of Korea," *Crop Monitor*, August 13, 2020, https://cropmonitor.org/index.php/cmreports/special-reports.
[10] Peter Makowsky, Jenny Town and Samantha Pitz, "North Korea's Hydroelectric Power – Part I," *Tearline*, July 4, 2019, https://www.tearline.mil/public_page/north-koreas-hydroelectric-power-part-i.
[11] Peter Makowsky, Jenny Town and Samantha Pitz, "North Korea's Hydroelectric Power – The Tanchon Power Station," *Tearline*, October 12, 2019, https://www.tearline.mil/public_page/north-koreas-hydroelectric-power-the-tanchon-power-station-project/.

"dark fleets"—vessels that do not publicly broadcast their location or appear on public monitoring systems—operating in North Korean waters.[12] The study used a combination of optical imagery to detect the presence and activity of pair trawlers; SAR imagery and nighttime optical imagery (Visible Infrared Imagery Radiometer Suite) to identify and distinguish different fleets of lighting vessels; combined with Automatic Identification System data, observational data from the South Korean coast guard, written evidence of illegal fishing operations and other open source data.

The study found that the scale of illegal Chinese fishing in North Korean waters, at least some of which were found to have North Korean fishing permits, involved more than nine hundred vessels in 2017 and seven hundred in 2018, despite a ban on the sale of North Korean fishing rights established under UN Security Council Resolutions 2371 and 2397 as well as under corresponding Chinese laws.[13] According to the report's coauthor Jaeyoon Park, senior data scientist at Global Fishing Watch, the fleet engaged was roughly one-third the size of China's entire distant water fishing fleet, calling this the "largest known case of illegal fishing perpetrated by vessels originating from one country operating in another nation's waters."[14]

The range of studies included in this article are only a small sampling of the broad and diverse ways in which satellite imagery has helped piece together a greater understanding of what is happening in North Korea. From monitoring of large construction projects, to examining dual-use facilities, to investigating illegal smuggling activities, satellite imagery is empowering analysts to produce innovative and original data-driven research in a data scarce field of study.[15]

Making Sense of Fleeting Moments

Satellite imagery can help improve understanding of what is happening inside North Korea in numerous ways despite several challenges to interpreting that data in accurate, meaningful and responsible ways with broad implications for incomplete or overreaching analysis.

Pictures can make for a compelling story, especially on topics where the audience has little prior technical knowledge of the subject area. In the current 24-hour news and social media environment,

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[12] Jaeyoon Park et al., "Illuminating dark fishing feels in North Korea," *Science Advances* 6, no. 20 (July 22, 2020), https://advances.sciencemag.org/content/6/30/eabb1197.

[13] Coauthor Jaeyoon Park, senior data scientist for Global Fishing Watch, reported a follow-up event that similar numbers of vessels were spotted in 2019 and 2020 (https://www.stimson.org/event/untangling-the-impact-of-illegal-fishing-in-north-korean-waters/).

[14] Sarah Bladen, "Report Exposes Rampant Illegal Fishing in North Korean Waters, Global Fishing Watch, July 22, 2020. https://globalfishingwatch.org/press-release/illegal-fishing-north-korea. Although this type of activity had been reported by the UN Panel of Experts (POE) in their final reports in 2019 and 2020, their reporting did not provide a sense of the scale of these operations.

[15] Samantha J. Pitz and Peter Makowsky, "Pyongyang General Hospital: A Bright White Beacon After the Rains," *38 North*, September 24, 2020, https://www.38north.org/2020/09/pyongyang092420; Margaret Croy, "OP #47: Dual Use in the DPRK," James Martin Center for Nonproliferation Studies, April 6, 2020, https://nonproliferation.org/op-47-dual-use-in-the-dprk; Catherine Dill, Cameron Trainer, Joseph Byrne, Gary Somerville, and James Byrne, "Project Sandstone 3: On the Trail of the Tae Yang: AIS Spoofing and North Korean Coal Smuggling," Royal United Services Institute, June 26, 2019, https://rusi.org/publication/other-publications/project-sandstone-3-trail-tae-yang-ais-spoofing-and-north-korean-coal.

news about North Korea spreads globally at lightning speed. Once a narrative is out in public with purported photographic evidence, it is impossible to retract and difficult to correct.

Satellite imagery analysis can be challenging, especially when the imagery resolution is insufficient to confidently determine what is being observed. While anything one meter or less is considered high-resolution imagery, viewing a site at even 0.5-meter resolution leaves a lot of room for interpretation. People look like dots and large boxes or crates may look similar because of their shapes and dimensions. Trained analysts work to make sense of what is observed based on experience and technical expertise about what should be there and what would make sense in that particular situation, but also factor in other possibilities if the image is truly unclear.

Moreover, a satellite image may provide a clear aerial view of a specific place at a specific moment of time but not context—more information is needed. When monitoring North Korea's WMD program facilities, for instance, baselines of activity are necessary to understand how recent activity in a single image relates to the site's normal patterns of life. For instance, large trucks around a missile related facility may indicate unusual or suspicious activity. But determining what is "unusual" requires an understanding of what a normal level of traffic is in and around that site over a longer period.

Unfortunately, baseline assessments are not always taken into account. Depending on the level of detail is needed, researchers may not always have access to enough recent high-resolution imagery to determine what is normal. In some cases, this may be due to budget restrictions, as discussed. Depending on the area of interest, though, a wealth of historical imagery may not always be publicly available either. Satellite companies, for instance, often prioritize collection of areas of high interest, both for the strategic value as well as an assumed level of marketability for that imagery, and more obscure sites or more rural areas of lesser strategic consequence may have limited coverage. Further, in a field where competition is increasing, analysts may also feel pressured at times to rush their analysis and make determinations with less information than ideal in order to be the first to publish.

Activity viewed out of context can easily be misconstrued, especially when it appears consistent with something suspicious, such as preparations for missile or nuclear weapons testing. For example, in September 2020, an unusually large assembly of vessels were observed berthed inside the secure boat basin at North Korea's Sinpo South Shipyard. Under normal conditions, this would be strongly suggestive of preparations for a submarine-launched ballistic missile test.[16] In context—the area had just been hit by a destructive typhoon and another was hours away—the probability that a test was being prepared under those conditions was diminished. Although test preparations could not be fully ruled out, the vessels were more likely positioned in the basin to protect them from heavy storms.[17]

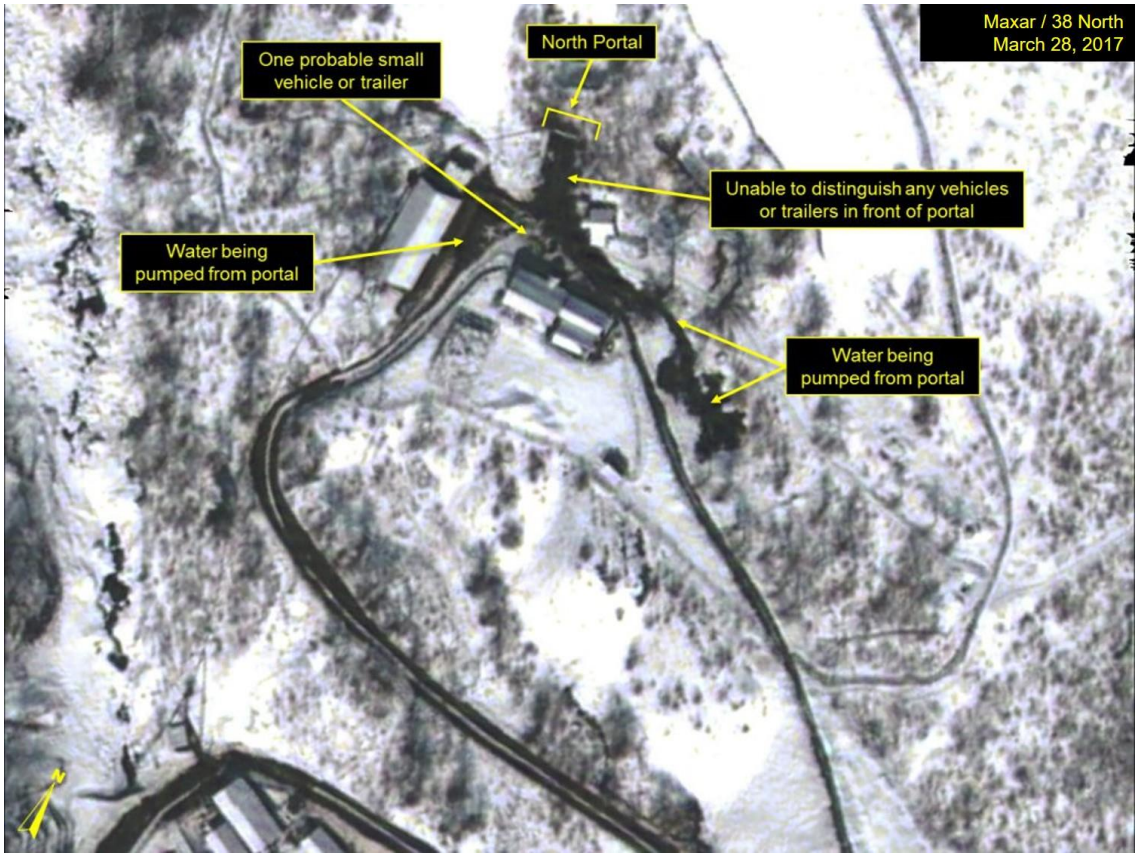
[16] Joseph Bermudez and Victor Cha, "Sinpo South Shipyard: Preparations for a Pukfuksong-3 SLBM Test?" *Beyond Parallel*, September 4, 2020, https://beyondparallel.csis.org/sinpo-south-shipyard-preparations-for-a-pukguksong-3-slbm-test.

[17] Peter Makowsky and Jack Liu, "Sinpo South Shipyard Braced for Stormy Weather," *38 North*, September 4, 2020, https://www.38north.org/2020/09/sinpo090420.

Another point to consider is that satellite imagery is not without some level of curation. Some mobile applications, for instance, track the location of orbiting satellites, allowing users to estimate when they may be overhead. If the North Koreans are using these or similar tools, they could also plan their activities accordingly—including potentially refraining from certain revealing activities when satellites are expected to pass overhead as well as deliberately conducting suspicious-looking activities as part of a deception campaign.

In March 2017 at the Punggye-ri nuclear test site, for example, activity consistent with nuclear test preparations was observed around the North Portal, the tunnel complex where four previous nuclear weapons tests had been conducted. It started with the appearance of a large crate or trailer around the portal. Over the next few weeks, the activity increased: pumping water out of the test tunnel, laying cabling leading to the portal, and draping camouflage netting over equipment just south of the portal's support building.[18] For all intents and purposes, the portal appeared to be ready for the conduct of an underground nuclear test by mid-April.[19]

Figure 1. Heightened activity at the North Portal of the Punggye-ri Nuclear Test Site, suggestive of nuclear test preparations.



Source: Image © 2017 Maxar Technologies.

[18] Joseph S. Bermudez Jr. and Jack Liu, "Heightened Activity at North Korea's Punggye-ri Nuclear Test Site," *38 North*, March 29, 2017, https://www.38north.org/2017/03/punggye032917.
[19] Joseph S. Bermudez Jr. and Jack Liu, "North Korea's Punggye-ri Nuclear Test Site: Primed and Ready," *38 North*, April 12, 2017, https://www.38north.org/2017/04/punggyeri041217.

Figure 2. By April 12, activity was consistent with the completion of test preparations.

Source: Image includes material Pleiades © CNES 2017. Distribution Airbus DS / Spot Image.

The nature of this activity was consistent with what had been observed in the weeks prior to North Korea's February 2013 nuclear test, which was heavily reported on at the time. The timing made sense as well, in that it would have positioned the North to be able to conduct a nuclear weapons test around a key North Korean holiday such as April 15, the Day of the Sun (Kim Il Sung's birthday) or even April 25, Korean People's Army Founding Day. But while the context of the activity made sense, one question loomed: why would North Korea reveal this activity?

North Korea had conducted two nuclear tests in 2016 for which no obvious indicators had been observed in the days or weeks prior, clearly demonstrating the ability to camouflage or conceal test preparation activities from remote sensors. Therefore, why would the North Koreans allow test preparation activities to be detected this time around? Were they really preparing for a test? Were they trying to threaten a test without actually planning to do so or without officially committing to conducting one? Did they prepare for a test and then decide not to go through with it?

To this day, the North's intention in that case is still unclear. 38 North's reporting of the activity at the time was hedged to include the range of possibilities for why this type of activity was taking place, even though the easiest explanation was that preparations were under way for a forthcoming test. In the end, North Korea did not conduct a nuclear test in April 2017. Instead, on at least one

of the holidays, it appeared the North Koreans were engaged in volleyball games throughout the various courtyards around the complex.

Figure 3. Probable volleyball games in progress throughout Punggye-ri Nuclear Test Site.

Source: Image © 2017 Maxar Technologies.

In this instance, understanding the context and a baseline of activities did not bring clarity to what was observed on the imagery. It did, however, underscore the need to constantly factor potential deceptive practices into the analysis—a practice North Korea analysts know all too well. But this case also served as a clear demonstration of how Pyongyang was adapting to a highly monitored environment.

Coverage of the nuclear test preparations in 2013 provided the North Koreans with the knowledge that the site was being monitored by nongovernmental actors, as well as clues as to what types of activities were noted. They therefore altered their test preparation practices in 2016 to be able to go unnoticed. In 2017, they demonstrated the ability to curate what activity would be captured by remote sensors to suit their purposes—whether technical, political, or both.

The North's adaptation to increased satellite monitoring has been observed not only in its practices, but also in its WMD infrastructure. One of the more extensive examples are modifications to facilities at the Sohae Satellite Launching Station, Pyongyang's showcase space launch complex. Following widely publicized coverage of its two satellite launch attempts in 2012, North Korea began upgrading the site to not only accommodate larger rockets, but also to better conceal rocket launch preparation and engine testing activities.

In 2012, for instance, rocket stages were observed being delivered to the site via rail, which were then transferred to the motor pool adjacent to the horizontal assembly building until they were ready to be assembled. Once the rocket was checked out and assembled, it was transferred to the launch pad via truck and driven to the launch tower. There, it would be placed by crane into the tower until it was ready to launch.[20] Coverage by 38 North of this preparation process allowed for timelines to be created and estimates to be made about when the North might be ready to launch.

It did not take long, however, before the North Koreans modified their infrastructure to better conceal their launch preparation activities. In 2015, they built shelters over the rail spur, obscuring the arrival of trains (that would carry rocket stages).[21] They extended the rail line to deliver the rocket stages directly to the launch pad and built a vertical assembly building and transfer structure on the launch pad, facilities that would conceal any movements associated with the rocket being checked out, assembled, or transferred to the launch tower. They also built permanent environmental covers around the launch tower platforms, obscuring the view of anything within them.

This meant from delivery of the stages to the site to the moment it was ready to launch, the rocket could be sheltered from optical satellite view. Video footage from the February 2016 satellite launch, indicated that North Korea had even taken the precautions to conduct Kim Jong Un's site visit of the launch site at night, avoiding satellite capture of the associated extra traffic or activity that could have provided clues that the rocket had arrived and the launch time was near.

Figure 4. Shelters erected over the rail spur at Sohae.

Source: left, © Maxar Technologies, 2015; right, © Airbus Defence & Space, includes material Pleiades © CNES 2015.

[20] See, for instance, Nick Hansen, "North Korea Readies the Unha-3 for Launch on April 12, 2012," *38 North*, April 12, 2012, https://www.38north.org/2012/04/nhansen041112.
[21] Tim Brown and Jack Liu, "Support Future SLV Launch; Preparations for Engine Testing Identified," *38 North*, July 28, 2015, https://www.38north.org/2015/07/sohae072815.

Figure 5. The launch pad just before the December 2012 satellite launch (left); and after the construction of on-pad facilities in 2015.

Source: left, © Maxar Technologies, 2012; right, © Airbus Defence & Space, includes material Pleiades © CNES 2015.

These kinds of adaptations make it more difficult to detect launch-related activities via satellite imagery and allow the North Koreans to curate what remote sensors capture. In some cases, this means keeping certain activities out of view. In other cases, it may mean taking deliberate actions such as moving the transfer structure at odd times to raise questions about the purpose of its movement: did it move because a rocket is being transferred to the launch tower or could it simply be movement of an empty structure with no purpose other than to deceive?

Consequently, although satellite imagery has created opportunities for the external world to view developments in North Korea, the North Koreans have also learned more about the tradecraft of imagery analysis. This does raise serious questions about what is an acceptable level of two-way learning and is one of many factors that have led to discussions about the ethics of publishing satellite imagery analyses.

Conclusion

The proliferation of satellite imagery has created a number of ways to conduct data-driven research about what is happening in a country where access is generally limited. From broad national or regional trends and sector-wide studies, to focused monitoring of secure facilities, satellite imagery provides windows into the country that the government has worked hard to obscure. When combined with other sources of information, it helps improve understanding of how the country is developing, what the regime prioritizes, and when and where problems may be looming.

Analysis, backed with purported photographic evidence, has enormous influence and media cycles are swift. Hasty or incomplete analysis can quickly lead to a wide spread of misinformation or disinformation, even if unintentional. This places a heavy burden on imagery analysts to their due diligence, to be objective and precise, and to acknowledge varying levels of uncertainty in their analysis, despite any pressure to tell a good story.

The persuasive power of imagery and the two-way learning that can occur from imagery analyses are among a number of factors that have led to questions about the ethics of publishing these kinds of studies. Although currently no set standards or guidelines are in place for ethical conduct in the field of imagery analysis, concern is growing among practitioners and preliminary groundwork is under way to help foster and promote more responsible practices, peer review, and accountability.[22]

Moreover, as much as analysts should strive for careful and conscientious analyses, the media should also take seriously the implications of sensationalized or inaccurate reporting of these studies. Because photographs appear to corroborate a narrative that is difficult change once it is in the public psyche, journalists should work to gain an accurate understanding of conclusions drawn from these studies and report them in an equally conscientious way to avoid spreading misinformation about issues of national security concern.

[22] Ben Loehrke, Laura Rockwood, Melissa Hanham, and Luisa Kenausis, "The Gray Spectrum: Ethical Decision Making with Geospatial and Open Source Analysis," Stanley Center for Peace and Security, July 2019, https://stanleycenter.org/wp-content/uploads/2020/01/RRNW-TheGraySpectrum120-web.pdf.

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North Korea Economic Forum (NKEF) is part of the policy program at the George Washington University's Institute for Korean Studies (GWIKS). The Forum aims to promote the understanding of North Korean economic issues, distribute well-balanced, deeply researched, and multi-dimensional insights on the North Korean economy and to expand networks among various North Korea watchers, scholars, and policymakers. The Forum mostly involves closed and off-the-record meetings, where participants can freely and seriously discuss critical issues. Mr. Daniel Wertz is currently the chair of NKEF and is leading the meetings. NKEF also organizes special conferences made public throughout the academic year. The Forum is made possible by a generous grant provided by the KDI School of Public Policy and Management.