



September 2016: Monitoring Activities at the Yongbyon Nuclear Site

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September 20, 2016 (Rev.1)

Commercial satellite imagery from July and August 2016 shows continued activity at the Yongbyon nuclear site, a major site for plutonium and weapon-grade uranium production for nuclear weapons. A recurring mystery is the operational status of the 5 megawatt-electric (MWe) reactor and the amount of plutonium produced there. Recent imagery suggests that its operation remains limited. In addition, a question is when the experimental light water reactor (LWR) will start. This new reactor could make considerably more weapon-grade plutonium than the 5 MWe reactor. Given the importance of plutonium to North Korea's nuclear weapons program, another question remains whether North Korea will seek to boost plutonium production at these two reactors by getting the smaller one to work better and starting the larger one.

The recent campaign to separate plutonium at the Radiochemical Plant may be finished. Recent imagery shows little activity there. An earlier Institute report estimated that North Korea could have separated about 5.5 to 8 kilograms of plutonium during this campaign, which is roughly enough for 1 to 4 nuclear weapons. This level of plutonium production is less than nominal and implies the reactor is not working as well as possible.

The outward construction of the possible tritium separation facility appears to be largely complete. This facility could increase North Korea's separation of tritium. Tritium is critical to the development and deployment of more powerful thermonuclear weapons, particularly designs aimed at significantly increasing the explosive yield of an atomic explosion.

5 Megawatt-Electric Reactor and Experimental LWR

The 5 megawatt-electric (MWe) reactor is the site where North Korea produces plutonium in natural uranium fuel. DigitalGlobe commercial satellite imagery dated August 26, 2016 showed no outward signs of full power, such as extensive water discharge into the nearby river or steam venting from the reactor's turbine structure(see figure 1). An Airbus commercial image dated July 14, 2016 also shows no water or steam discharge (Also figure 1).

The August 28 image depicts vehicles, including what appears to be a flatbed truck, at the building's entrance as well as additional, unidentifiable new objects. Although this implies activity at the reactor site, the nature of the activity is unknown. The flatbed truck that is present at the building's entrance appears to be the same truck previously identified in a May

22, 2016 image and possibly the July 14, 2016 image. This suggests this vehicle is regularly used or scheduled for use; however, its purpose is unknown.

Our assessment is that the reactor has operated intermittently or at low power since mid-2014.¹ Based on the recent imagery, we do not detect evidence of consistent operation at full reactor power in July and August 2016. Although North Korea has conducted extensive renovations of the reactor during the last several years, including importing equipment and materials from abroad, the reactor's operation may remain sporadic.

Based on information of a knowledgeable government expert, the nominal thermal power of the reactor is likely only in the range of 15-20 megawatts-thermal. Originally, the reactor's nominal power was in the range of 20-25 megawatts-thermal. However, it is unclear if the reactor is reaching even these reduced power levels on a consistent basis.

On August 19, 2016, the International Atomic Energy Agency (IAEA) released an annual report, *Application of Safeguards in the Democratic People's Republic of Korea*, discussing activities at the Yongbyon site.² According to the report, "For most of the reporting period [the last year] there were indications consistent with the reactor's operation, including steam discharges and the outflow of cooling water. However, between mid-October and early December 2015 there were no such indications. This period is sufficient for the reactor to have been de-fueled and subsequently re-fueled. Based on past operational cycles, a new cycle commencing in early December 2015 can be expected to last about two years." The IAEA has apparently concluded that the fuel in the core of the reactor was removed and new fuel inserted by the end of 2016. However, the report does not provide any information about the level of reactor operation.

Radiochemical Laboratory and Nuclear Waste Facilities

The Radiochemical Laboratory is where North Korea chemically processes discharged irradiated fuel from the 5 MWe reactor and separates plutonium for nuclear weapons. A government source confirmed in June 2016 that activities inside the main building of the Radiochemical Laboratory had recently taken place that implied the separation of plutonium. Based on commercial satellite imagery during the spring, the Institute could see activity was occurring that indirectly indicated that the spent fuel discharged from the 5 MWe reactor was being processed to extract plutonium. This activity included the presence of more vehicles than usual, modifications to waste sites at the complex, and the emission of smoke in the main stack at the coal fired steam generation plant, which is typically operated to produce steam used in

¹ See for example, "Update on North Korea's Yongbyon Nuclear Site," by David Albright and Serena Kelleher-Vergantini, Institute for Science and International Security, September 15, 2015 http://isis-online.org/uploads/isis-reports/documents/Update_on_North_Koreas_Yongbyon_Nuclear_Site_September15_2015_Final.pdf; and "Update on North Korea's Reactors, Enrichment Plant, and Possible Isotope Separation Facility," by David Albright and Serena Kelleher-Vergantini, Institute for Science and International Security, February 1, 2016. http://isis-online.org/uploads/isis-reports/documents/Yongbyon_January_2016_Update_Final.pdf

² IAEA Director General, *Application of Safeguards in the Democratic People's Republic of Korea*, GOV/2016/45-GC(60)/16, August 19, 2016, http://isis-online.org/uploads/iaea-reports/documents/North_Korea_IAEA_Report_19Aug2016.pdf

waste processing activities following the separation of plutonium from irradiated fuel. In a previous study,³ the Institute estimated that the separation campaign involved the processing of a full core of irradiated fuel from the 5 MWe reactor. The processing of a full core is estimated to have resulted in a total of 5.5-8 kilograms of separated weapon-grade plutonium, or enough for one to four nuclear weapons, assuming 2-4 kilograms of weapon-grade plutonium per weapon, or a central estimate of 2.5 nuclear weapons equivalent. This amount of plutonium is less than nominal. Accepting the IAEA's finding that the reactor fuel was discharged in late 2016, the fuel was in the reactor for somewhat more than two years. As a result, the average annual production of plutonium was about 2.5 to 4 kilograms.

The IAEA has concluded that North Korea has likely reprocessed fuel from the 5 MWe reactor in a campaign that likely ended by this summer. According to the IAEA's August 2016 report, "From the first quarter of 2016, there were multiple indications consistent with the Radiochemical Laboratory's operation, including deliveries of chemical tanks and the operation of the associated steam plant. Such indications ceased in early July 2016. In previous reprocessing campaigns, the Radiochemical Laboratory's operation involved the use of the spent fuel discharged" from the 5 MWe reactor.

The July 14 and August 28, 2016 imagery shows little activity at the Radiochemical Laboratory, including no smoke being emitted at the coal fired steam plant (see figures 2 and 3). As of August 28, there are only a few new objects, most likely vehicles and possibly sheds, in proximity to the spent fuel reception building (see figure 2). In addition, there is no obvious work around the nuclear-waste-related building 500, where earlier, trench work was being done next to the building (figure 4).

Experimental Light Water Reactor

The Experimental Light Water Reactor (LWR) is still under construction, although North Korea announced that the reactor would be finished several years ago. In the recent July and August imagery, there does not appear to be any external activity taking place (see figure 1). The lack of any activity is consistent with the August report of the IAEA. According to the IAEA report: "The construction of what appears to be an electrical switchyard adjacent to the LWR was completed in December 2015. The Agency has not observed indications of the delivery or introduction of major reactor components into the reactor containment building." When this reactor may start remains a mystery. In addition, although North Korea has stated that the reactor would concentrate of producing electricity, another question is whether it will also make plutonium for nuclear weapons. Given the age and size of the 5 MWe reactor and the importance of plutonium for making nuclear weapons, North Korea would have a strong incentive to finish the reactor and produce weapon-grade plutonium in it.

Suspected Isotope Separation Plant

³ David Albright and Serena Kelleher-Vergantini, "Plutonium, Tritium, and Highly Enriched Uranium Production at the Yongbyon," Institute for Science and International Security, June 14, 2016. http://isis-online.org/uploads/isis-reports/documents/Pu_HEU_and_tritium_production_at_Yongbyon_June_14_2016_FINAL.pdf

The possible isotope separation plant appears outwardly to be nearing completion (see figure 5). This facility is located east of the fuel fabrication complex and possibly slated at least in part to separate tritium and other isotopes for nuclear weapons purposes. This facility could increase North Korea's separation of tritium, which could benefit a program to make different types of thermonuclear nuclear weapons, particularly boosted designs.

External construction may be finishing at the site. June 2016 satellite imagery showed trucks and construction material, but the July 14 imagery shows the site to be relatively clean of construction material (see figure 5). Changes visible in the August 28 imagery include the covering of a seemingly empty water tank and the presence in close proximity of an object which could possibly be a gas tank.

Questions have arisen over whether this plant may be intended to separate plutonium from irradiated fuel. The Institute analysis relied partially on an assessment that the concrete walls of the hot cells appear too thin to provide adequate shielding for separating plutonium from irradiated fuel. However, we received a question as to whether North Korea could use advanced concrete that would allow thinner walls while providing the same radiation shielding as much thicker, regular concrete walls. We queried two experts who responded that North Korea is not prone to using advanced concrete and it usually uses simpler technology. Moreover, the experts pointed out that the internal structure of this building is composed of hot cells with what looks like laboratory space behind the cells.⁴ To them, artificial isotope separation makes more sense than plutonium separation.

Centrifuge Plant

The July and August 2016 images do not show significant external activity at the centrifuge plant, which is located in the fuel production complex and believed to be operational (see figure 6). In the August image, there appear to be vehicles located west of the main centrifuge building and new objects to the east of it, leading to the conclusion that construction may be happening nearby.

According to the August IAEA report: "There were indications consistent with the use of the reported centrifuge enrichment facility located within the plant. Additional construction work around the building that houses this reported facility has been ongoing."

⁴ See figure 4 in "Update on North Korea's Yongbyon Nuclear Site," by David Albright and Serena Kelleher-Vergantini, Institute for Science and International Security, September 15, 2015. [http://isis-online.org/uploads/isis-reports/documents/Update on North Koreas Yongbyon Nuclear Site September15 2015 Final.pdf](http://isis-online.org/uploads/isis-reports/documents/Update_on_North_Koreas_Yongbyon_Nuclear_Site_September15_2015_Final.pdf)

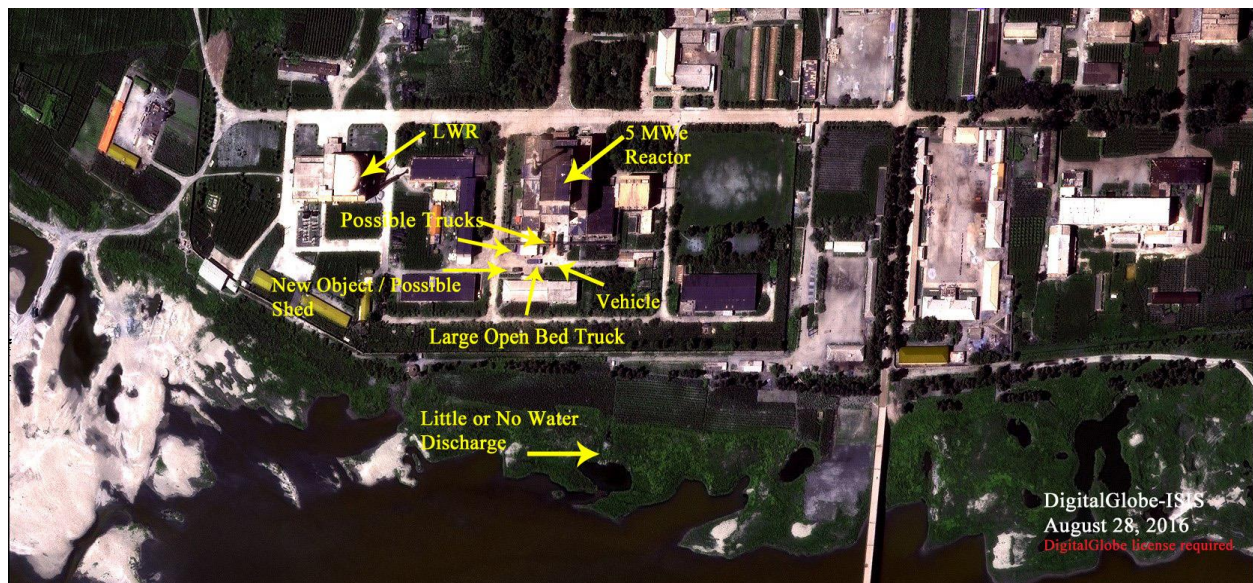


Figure 1: Commercial satellite imagery showing North Korea's 5 megawatt-electric reactor and Experimental LWR on July 14, 2016 and August 28, 2016.

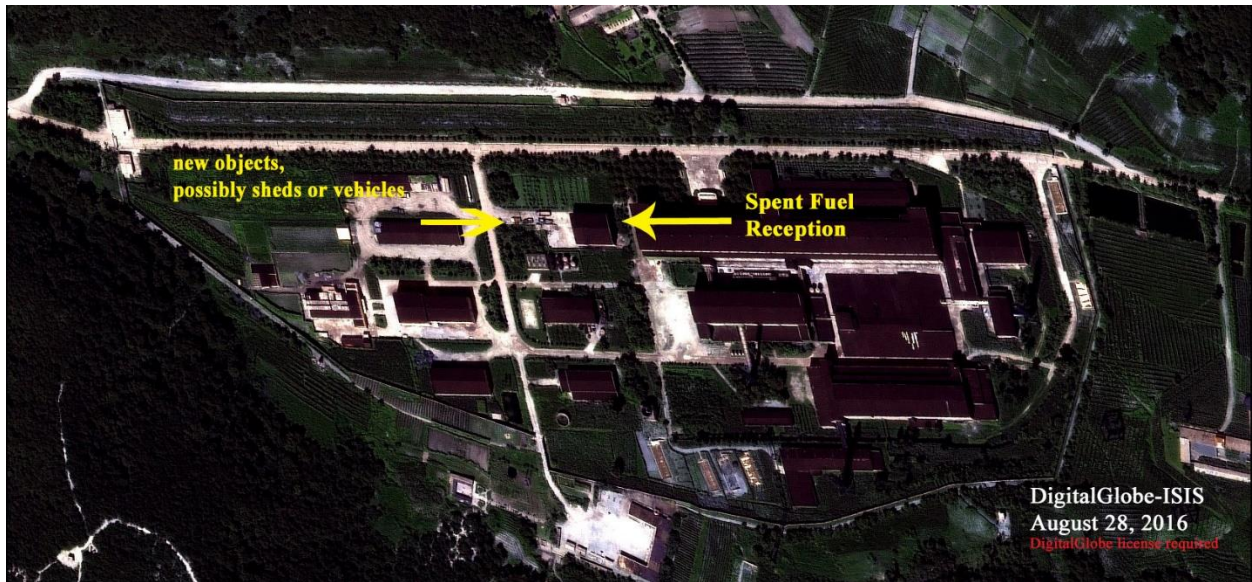


Figure 2: Commercial satellite imagery showing North Korea's Radiochemical Laboratory on July 14, 2016 and August 28, 2016.



Figure 3: Commercial satellite imagery showing North Korea's coal fired steam plant on July 14, 2016 and August 28, 2016. No smoke is emerging from the stack.

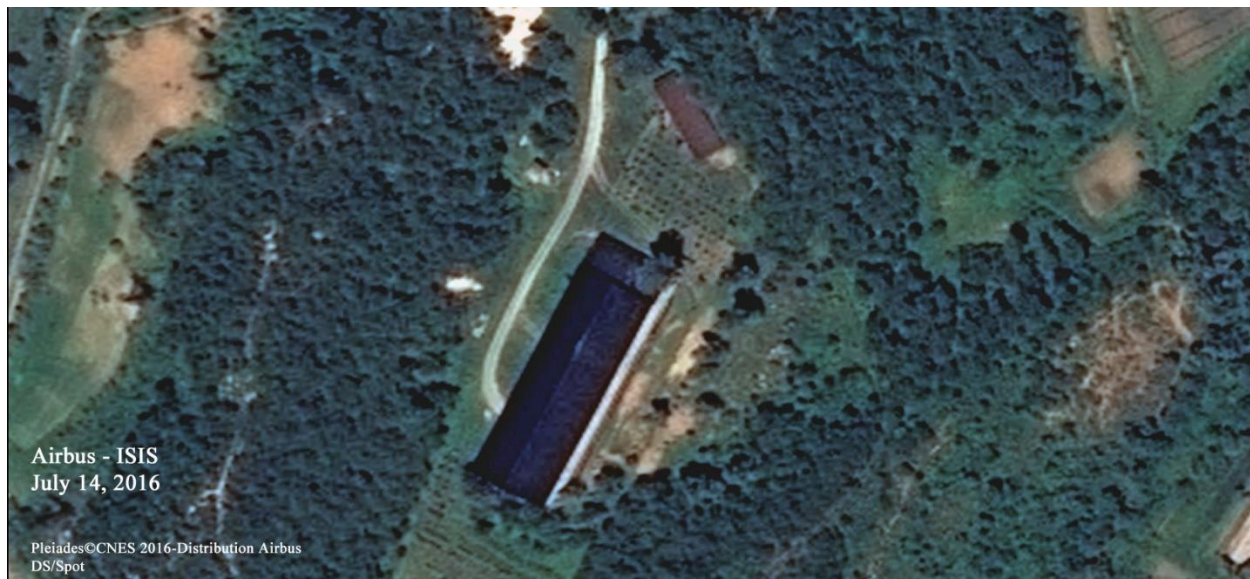


Figure 4: Commercial satellite imagery showing North Korea's Building 500 on July 14, 2016 and August 28, 2016.

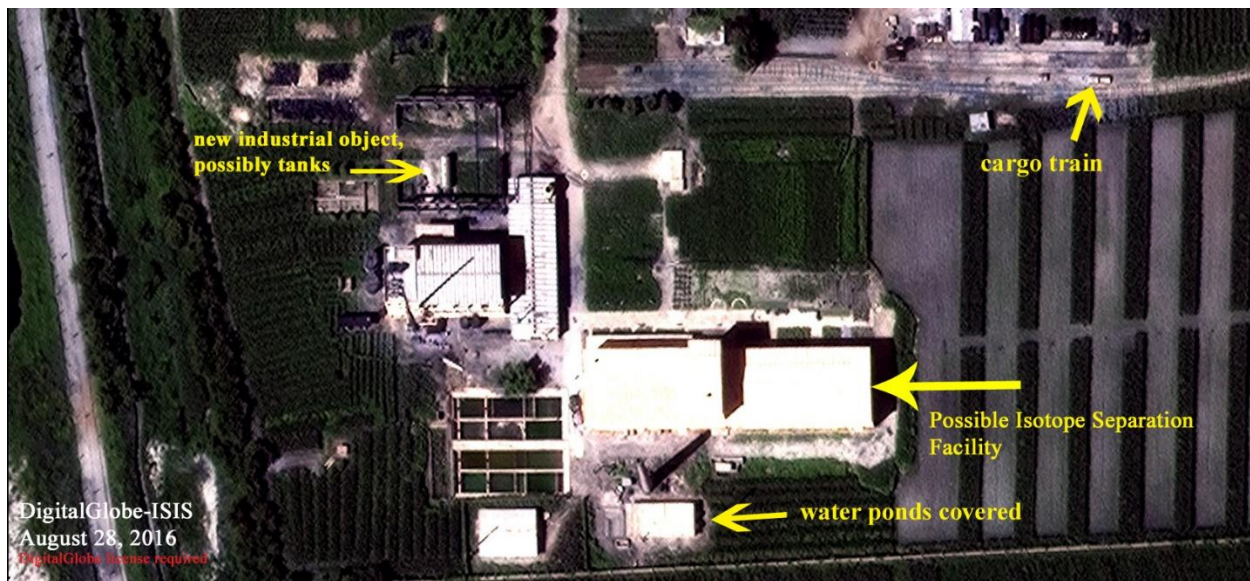


Figure 5: Commercial satellite imagery showing North Korea's suspected isotope separation plant on July 14, 2016 and August 28, 2016.

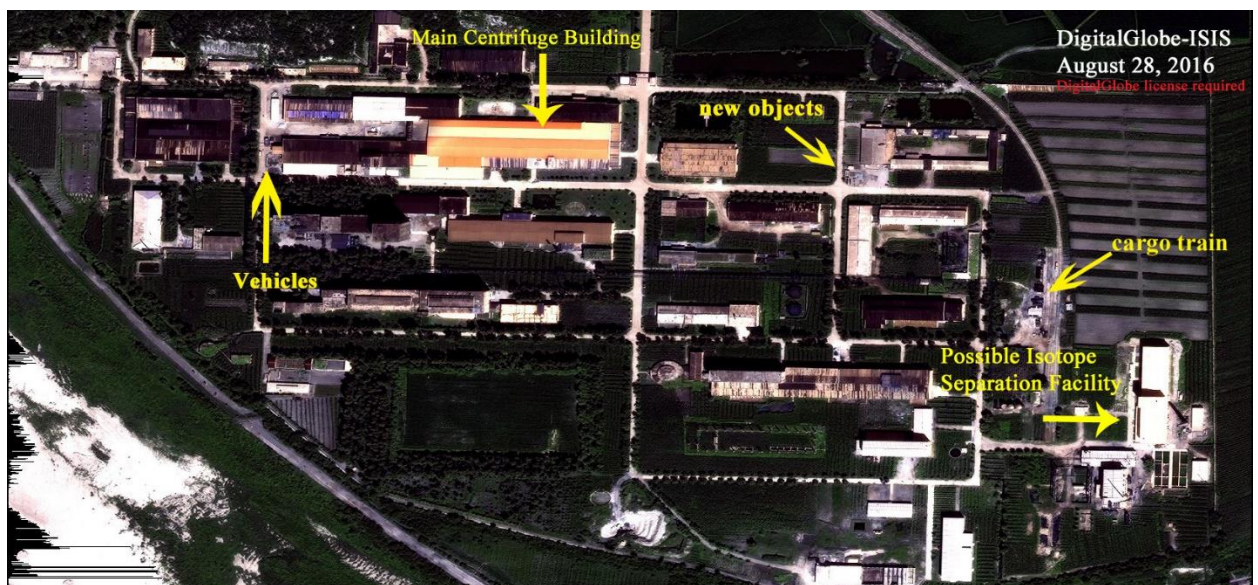
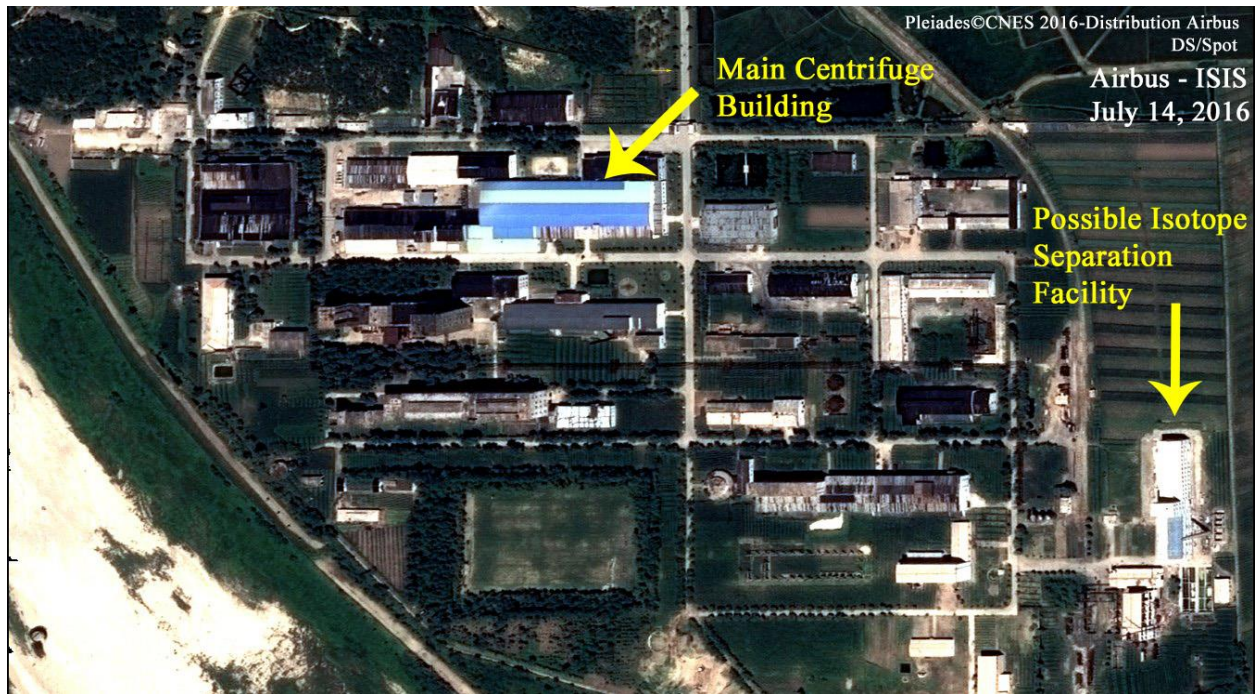


Figure 6: Commercial satellite imagery dated July 14, 2016 and August 28, 2016 showing North Korea's centrifuge plant, which is located in the fuel production complex.