NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY

TEARLINE

PROJECT

2023 YEARBOOK

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MESSAGE FROM THE TEARLINE MISSION OWNER

At the National Geospatial-Intelligence Agency, we understand the success of our mission -- to provide world-class geospatial-intelligence and lead the global GEOINT enterprise -- is more achievable with support and unique perspectives from our partners at all levels.

The agency's Tearline effort, where academic and non-profit contributors supply open-source intelligence and grow authoritative reports for NGA, federal partner agencies and general public usage, is an example of how these partnerships can support and assist in the agency's mission.

Tearline leverages the agility and research of the commercial and academic sectors with access to emerging data, advanced analytics or applications. Through our connections with authors and readers, we hope to enhance NGA's academic outreach efforts, build new partnerships and accelerate technology transfer. Tearline also supports STEM programs, allows prospective employees the opportunity to work with NGA analysts and serves to attract talented Tearline authors into NGA's workforce.

We look to our Tearline partners, not only for thorough and thought-provoking articles relevant to world events and critical issues, but also as sources for innovative approaches related to GEOINT tradecraft, technology and techniques. Tearline goals are aligned to NGA's mission, strategic objectives and operational objectives.

On behalf of the entire Tearline team, I would like to introduce the inaugural Tearline yearbook, which collects a number of articles published in 2023. We're celebrating the collective accomplishments of numerous analysts, editors and many others from NGA along with academic institutions and non-profit organizations.

In the following pages, you'll discover a broad range of topics from around the globe and I hope you find as much utility in them as I did. Visit the Tearline website at www.tearline.mil for the latest and be sure to look for many more excellent Tearline articles in the coming year.

Robert B. Shields
Director, Office of Analytic Technology

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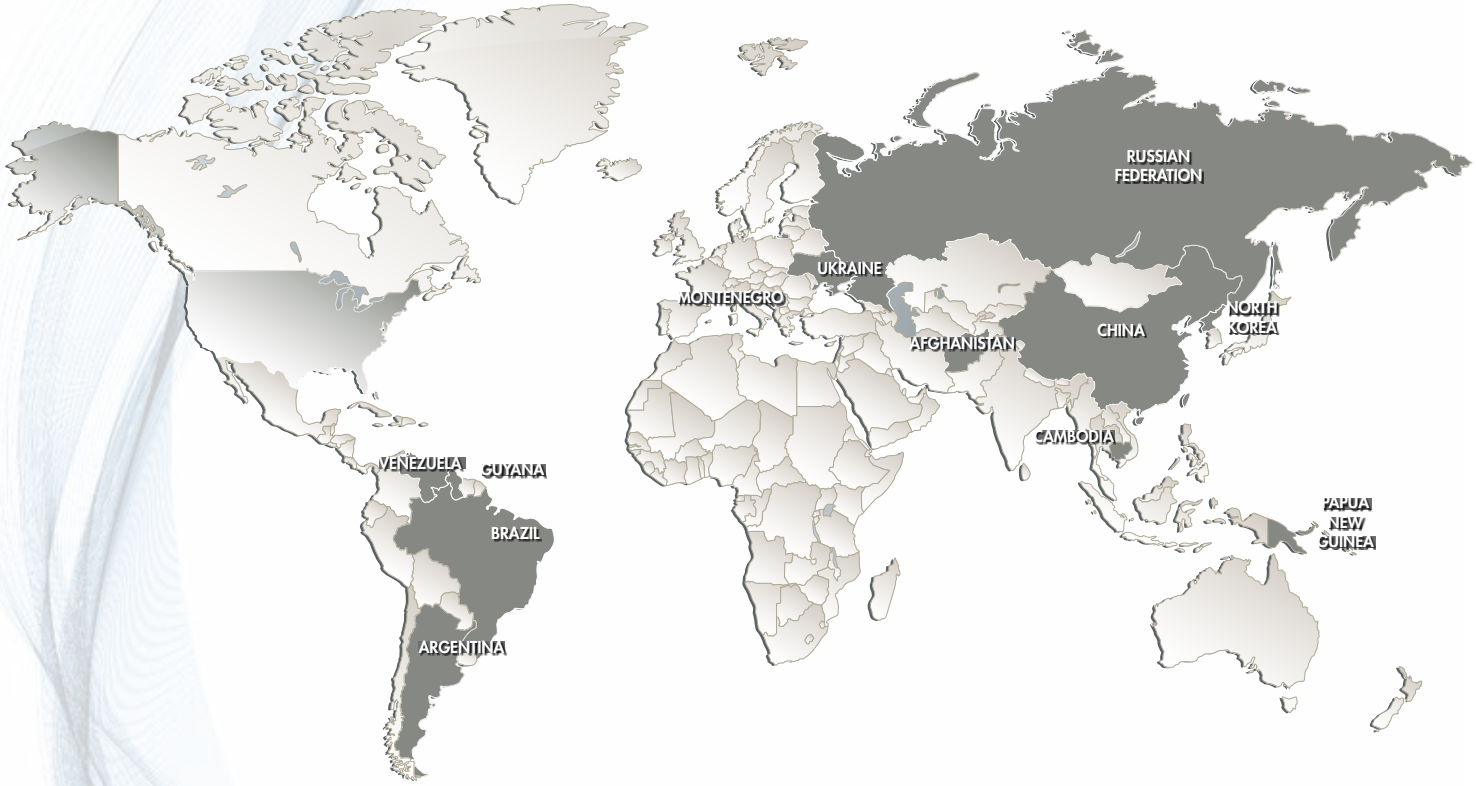
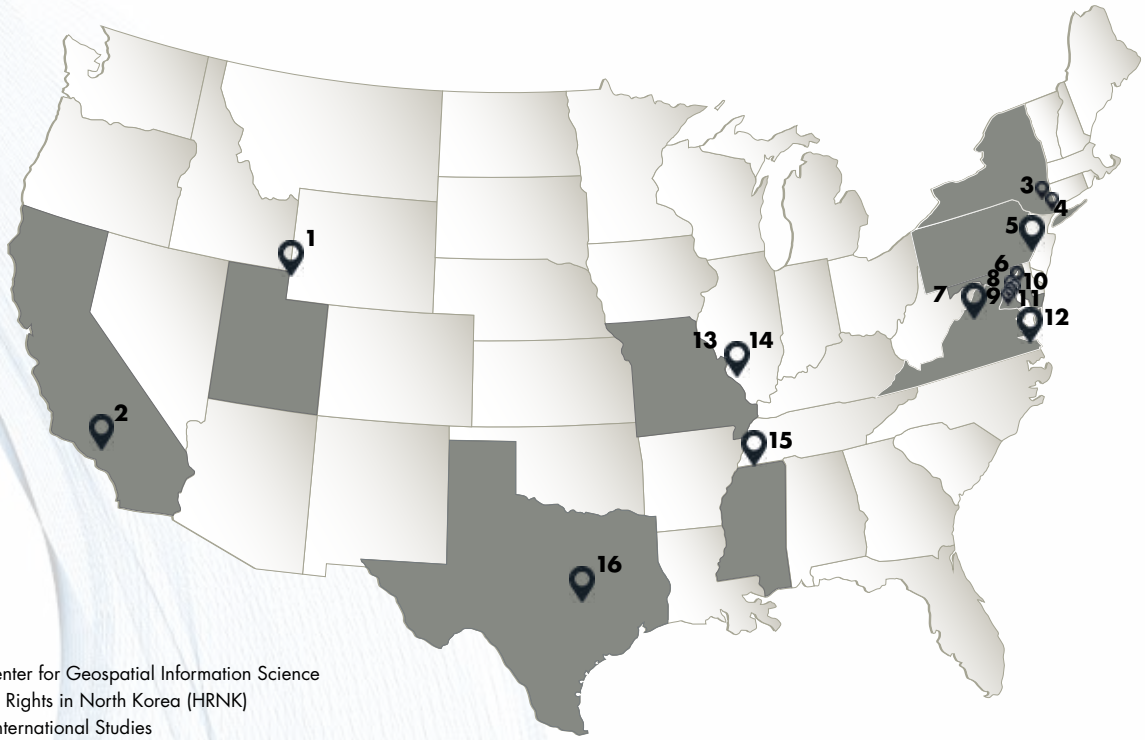


U.S. MAP OF SUBMITTERS



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China's Interests in Montenegro: Alternative Analysis Case Study - Debt Traps Revisited

In partnership with University of Mississippi and written by Sydney Lynch, Jonah Kocisko, Landon Lunsford, Zachary Partin, Lee Holmes, and Kevin Riehle

2023 OSINT Product of the Year AWARD

OVERVIEW

The Montenegrin-Chinese Belt Road Initiative (BRI) loan agreement of 2014 was expected to foster economic growth in Montenegro through the creation of a highway from Bar, Montenegro to Belgrade, Serbia. However, the high costs associated with this project ballooned Montenegro's debt to more than 100% of its GDP in late 2020.

This created not only a precarious economic position for the Balkan country but a risk of key government assets falling into the control of Chinese state-owned companies. The BRI loan agreement stipulates that a default on loan payments would allow Chinese state banks to pursue legal recourse that places the ownership of Montenegrin state-owned assets as recompense.

ACTIVITY

Although a loan payment default appears unlikely in the near future, several Montenegrin government-owned and government-backed assets could be vulnerable to a transfer of ownership should default ever occur. This analysis will survey what assets could be placed into Chinese control, and of these which are most likely to be targeted by Chinese interests in the event that Montenegro defaults on its loans. This alternative outcomes analysis (or red cell analysis) can serve as a warning function to one of the more aggressive BRI loan cases with a unique asset transfer stipulation in the agreement.

FINANCIAL AND LEGAL OVERVIEW OF MONTENEGRO'S LOANS

Montenegro's financial situation is currently stable as of March 2023 with a Debt-to-GDP ratio of 68.2%, below the World Bank's threshold of 77% where debt can negatively impact economic growth. This is a significant decrease from 103.5% in December 2020, indicating that the country has made some progress in reducing its national debt. However, Montenegro's economy is small, with a GDP of $5.86 billion in 2021, making it vulnerable to external shocks.

A portion of vulnerability centers around the $944 million loan from China's institutional Export-Import Bank (Exim) with an initial 2% interest rate that was later hedged in July 2021 with help from French and U.S. Banks to 0.88%. Montenegro made its second loan payment of $32.8 million in early 2022 which included the new arrangement with U.S. and French banking help. The new loan structure from hedging helps reduce some risk and is projected to save Montenegro $8.8 million annually. However, the overall size of the debt and repayment is still a concern to banking and other economic observers, for example, at the International Monetary Fund and World Bank, especially when viewed through the prism of Montenegro's pending European Union (EU) status and concerns over China's influence in the Balkans. The EU prefers to see a debt-to-GDP ratio below 60% for financial health considerations.

At any rate, the original legal agreement that Montenegro signed with China when taking out the loan includes a clause that could lead to the transfer of state assets if the country fails to repay the loan.

The relevant text in the legal agreement states:

8.1 The Borrower hereby irrevocably waives any immunity on the grounds of sovereign or otherwise for itself or its property, except for those assets dedicated to military or diplomatic purpose, in connection with any arbitration proceeding pursuant to Article 8.5 hereof or with the enforcement of any arbitral award pursuant to Article 8.5 hereof.

8.4 This Agreement as well as the rights and obligations of the parties hereunder shall be governed by and construed in accordance with the laws of China.

8.5 Any dispute arising out of or in connection with this Agreement shall be resolved through friendly consultation. If no settlement can be reached through such consultation, each party shall have the right to submit such dispute to the China International Economic and Trade Arbitration Commission (CIETAC) for arbitration.

Clause 8.5, known as the "waiver of immunity" clause, stipulates that should Montenegro fail to repay the agreed amount back to China, the Montenegrin ownership of government-owned and government-backed sites and assets could be revoked by a Chinese arbitration court. Afterward, the ownership of these assets could be sold directly to Chinese state-owned firms.

Methodology

The methodology employed for this study involved a two-phase approach. First, we used commercial imagery to locate and qualitatively analyze Montenegro's critical infrastructure, which is relatively concentrated around certain geographical areas due to the country's small size. We assessed each site for factors such as size, condition, and the goods or services it provides. In addition, we confirmed that these sites were indeed state-owned or substantially backed with state ownership through open source resources.

Our state-owned and state-backed assets list is unique because some previous media reporting on China's "land seizure" scenarios in Montenegro used general language describing "land" or "property" where the reader could interpret private property seizures as part of the default. The BRI loan was inked with Montenegro's government and Montenegro has private property rights and protections so Chinese seizure of citizen-held private property seems outside the scope of the deal or worst-case scenarios.

Key assumptions

A key assumption in our assets list extends the meaning of state "property" or "assets" to mean government-owned or substantially government-backed enterprises, property, assets, and sites in Montenegro. This expanded language helps with alternative outcomes or red cell analysis of potential Chinese levers as the term "property" is not clearly defined in the original loan document and could mean government equities, securities, and positions as "property" in worst-case scenarios. Finally, Montenegro is a small country where literal government "property" (defined as real estate such as government buildings) may not be independently sufficient as collateral for such a large loan.

In the second phase, we researched China's past BRI partner nations and their critical infrastructure. This allowed us to identify China's historical interests in critical industries and infrastructure, which we cross-compared with current Montenegrin capabilities to generate a list of sites that would be of potentially high interest to China if Montenegro were to default on the loan.

From this final list (Figure 1), we used commercial imagery and open-source data and reporting to assess the economic importance of these critical sites to Montenegro and their potential relevance to Chinese interests. This involved analyzing factors such as the volume of goods or services provided, the nature of the infrastructure, and any existing or potential connections to Chinese markets. By examining these factors, we were able to gain a more nuanced understanding of the potential impact of ownership transfers to Chinese state-owned companies on Montenegro's economy and its strategic position within the region. The reader can also fly to all the assets under study from the KMZ file in the Data Sources section. An ESRI Shapefile is also available for the primary locations.

Montenegro's Government-Backed Infrastructure

NAME	ASSET TYPE	MUNICIPALITY	COORDINATES
Port of Bar	Port	Bar	42.098, 19.089
Port of Kotor	Port	Kotor	42.425, 18.767
A1 Highway	Road	Multiple	42.569, 19.390
Montecargo	Rail Depot	Podgorica	42.431, 19.268
Željeznicka infrastruktura Crne Gore (ZICG)	Rail Infrastructure	Podgorica	42.435, 19.268
ŽELJEZNICKI PREVOZ CRNE GORE (ZPCG)	Railway Transport	Podgorica	42.432, 19.269
Podgorica Airport	Airport	Podgorica	42.399, 19.257
Berane Airport	Airport	Berane	42.835, 19.861
Tivat Airport	Airport	Tivat	42.405, 18.725
Bauxite Mine*	Mine	Nikšic	42.762, 19.082
Piva Hydro Plant	Electricity	Plužine	43.272, 18.842
Perucica Hydro Plant	Electricity	Nikšic	42.671, 18.995
Pljevlja Coal-fired Plant & Coal Mine	Electricity	Pljevlja	43.340, 19.370
Komarnica Hydro Plant (planned)	Electricity & Coal Mining	Šavnik (45 km upstream of Piva HPP)	42.988, 19.068
Gvozd Wind Farm (planned)	Electricity	Nikšic	42.791, 18.943
*Bauxite mining is private sector. See section below for complete breakdown of government backing of all other enterprises.			

Figure 1: Major government-backed infrastructure in Montenegro *Source: Original Work*

KEY ASSUMPTION: STATE-BACKED ENTERPRISE SOURCING

A standard operating model in Montenegro for major infrastructure is to charter a joint-stock company with the government taking a majority position, often a vast majority of the shares, in the enterprise.

For example, ZPCG is tasked with rail transport services for passengers and rolling stock in Montenegro, and the government holds 89% of the equity in the rail enterprise according to information on ZPCG's corporate website. In Montenegro, joint-stock company names are often noted with an "AD" after the enterprise name such as ZPCG AD. "AD" for "Akcionarsko Društvo" translates to "joint-stock company." The "CG" ending in many of the enterprise names stands for "Crne Gor," which is the local name for Montenegro.

- ZICG is tasked with the operation and maintenance of railway infrastructure in Montenegro. According to equity information listed on ZICG's website, the government owns 72.44% of the equity.
- Montecargo handles freight transport and the operation of freight wagons and locomotives within Montenegro. According to Montecargo's website, 87% of the equity is owned by the government.
- Aerodromi Crne Gore. According to the Airports of Montenegro website, was founded in 1999 by the Government of Montenegro. Podgorica and Tivat Airports are the main listings on the official website. The Berane Aiport is not listed on this website. See our assumption of ownership below.
  - o Berane Airport – In April 2023, the Prime Minister of Montenegro, Dritan Abazovic, signed a deal with a German company Elite-Private Jet Service to restore and revamp the airport. The memorandum is between the Government of Montenegro and the German company which implies government ownership of the airport like the others.
- The Port of Bar or "Luka Bar" ("Luka" means "port" or "harbor") is a public venture where the government owns a 78.55% stake in the port according to financial PDFs attached to the Port of Bar website dated 3/31/2023.
- The Port of Kotor's financial and ownership data was not as easily found on an authoritative website as it was with the Port of Bar. Port of Kotor was listed as a "state-owned firm" on a Montenegrin news site in 2019 and in March 2023 a website called "Montenegro Business" reported that the government was taking partial or full ownership of "port facilities" with an eye on finding more "tenders" in the future. Based on this, we assume the Port of Kotor is another heavily state-backed infrastructure asset.
- Montenegro's primary power company, Elektroprivreda Crne Gore (EPCG) follows a similar business structure to the rail transportation services. According to the official EPCG website, the government holds 88.1% of shares in the company.
- The roads are government assets, especially the Bar-Boljare Highway Section as it is a named entity in the original loan document signed by the government of Montenegro with China.
- As for the bauxite mines in Montenegro, Uniprom is the primary enterprise that focuses on bauxite mining and aluminum production. According to the Uniprom website, the entire company is 100% owned by Mr. Veselin Pejovic the founder and director of the Uniprom group. However, the Uniprom website also states that a sub-group, Uniprom Metal LLC Nikšic, is the "largest state-owned national mining corporation and the biggest national exporter of ore." A state-backed asset nested under a "100%" overall private claim could be fragmentary, contradictory, or out of date. We are simply stringing together the most complete picture regarding state-backed assets from the literature available online. Regardless of the sub-group listing, we still assume the mining enterprise is mostly in private hands, which is distinct from other assets where the government is heavily invested in the enterprise.
- Finally, we analyze a coal-fired power plant later in the text run by EPCG. There is a mining operation, Rudnik uglja Pljevlja, under EPCG control. The coal mine's official website (last updated in 2018) states that EPCG is the sole shareholder in the company. As mentioned above, 88% of EPCG shares are owned by the Montenegrin government.

Pie chart from ZPCG's website showing 89% state ownership ("Drzava" translates to "State")

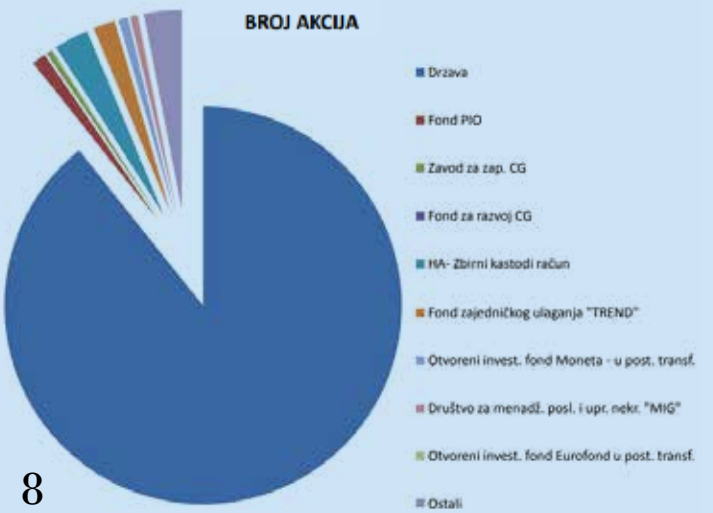


Table from EPCG website which breaks down the company ownership structure

The Company's ownership structure

Shareholders	In Register	In Depositary	Share (%)
State of Montenegro	-	-	88,1221
ELektroprivreda Crne Gore A.D. Nikšić	-	-	10,0000
A2A	-	-	0,5391
Others	-	-	1,3388
Total shares	**118.132.402**		**100**

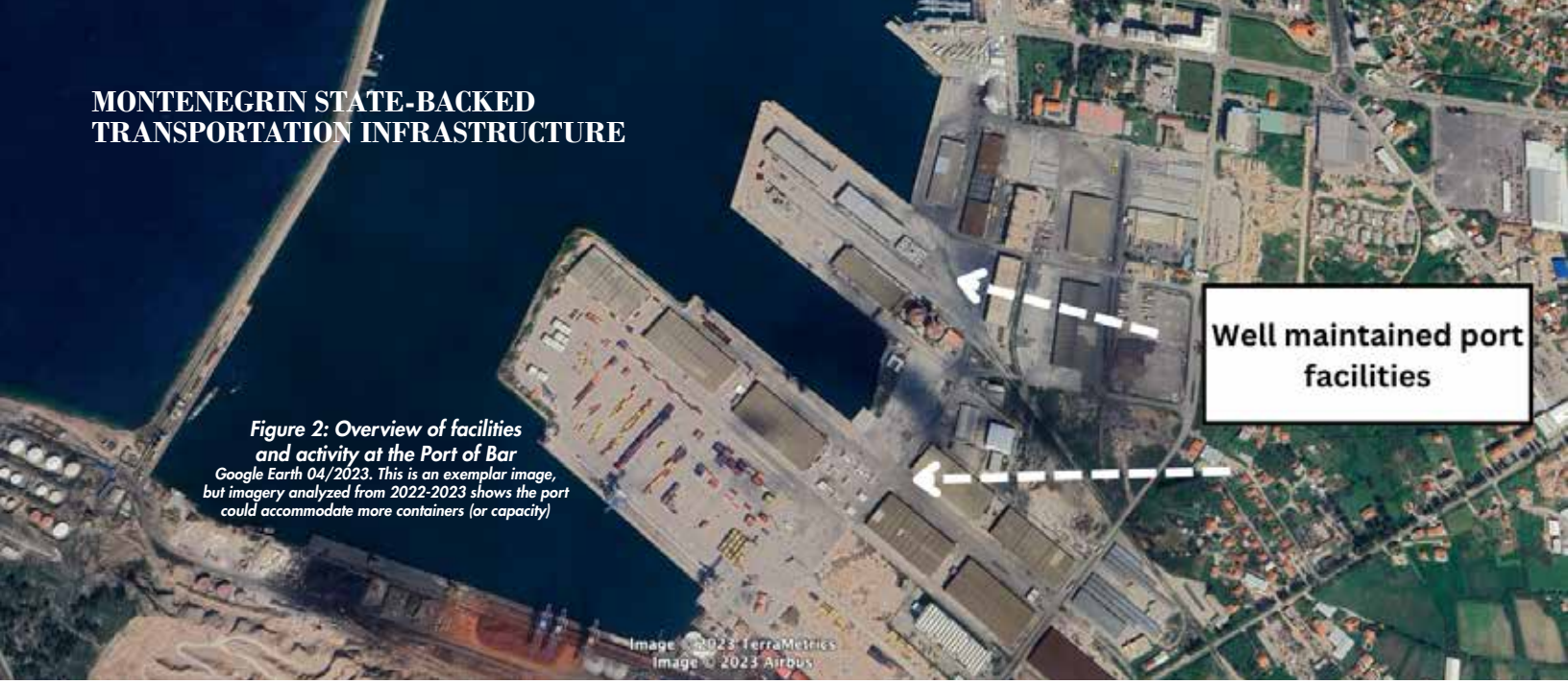


Figure 2: Overview of facilities and activity at the Port of Bar
Google Earth 04/2023. This is an exemplar image, but imagery analyzed from 2022-2023 shows the port could accommodate more containers (or capacity)

PORTS

Port of Bar

Montenegro has one primary cargo port, the Port of Bar. This port is connected to the country's capital, Podgorica, by several major transportation systems, including the country's major highways and railways. While there are other ports within the country, this is Montenegro's only cargo port and is a critical economic asset on which China is likely to focus its efforts.

China's investment in Montenegro's infrastructure would likely be part of a broader effort to expand its economic presence in the Balkans and strengthen its position in the region. From the Chinese perspective, owning a strategic cargo port in Montenegro would secure a central connection point between land and maritime trade throughout the Balkans.

The Balkans region, with its diverse economies and proximity to both Western Europe and Asia, presents opportunities for trade, investment, and market expansion. By securing control over the Port of Bar, China would strengthen its position as a key player in the Balkans, enabling Chinese companies to leverage trade routes and infrastructure to access and influence. Additionally, the Balkans region is rich in mineral resources, those nearest to the Port of Bar include aluminum-containing bauxite and lithium-containing jadarite sites.

This is in line with historical trends in China's strategic goals, where it has shown a strong interest in gaining control of key ports around the world, particularly those that are strategically located along major trade routes. This includes Sri Lanka, where China's investment in the port of Hambantota gave it a key foothold in the Indian Ocean. Additionally in Greece, its investment in the port of Piraeus allows it to access key European markets in the Mediterranean.

China would also likely look to expand and increase capacity at the port to further its economic influence and improve the efficiency of its trade routes. From imagery analysis, it appears the port is well maintained and active with some potential for capacity increases as Figure 2 illustrates.

The Port of Kotor serves both commercial and tourist traffic with an emphasis on tourism (Figure 3 and 4). According to the official Port of Kotor website, the number of yachts and tourists has steadily increased from 2001 to 2013 (see bar charts of increases).

Parts of the city and bay (small island fortifications and ancient structures) of Kotor are classified and protected by the UN as heritage sites. The United Nations Educational, Scientific and Cultural Organization (UNESCO) describes parts of Kotor as:

The Outstanding Universal Value of the Cultural-Historical Region of Kotor is embodied in the quality of the architecture in its fortified and open cities, settlements, palaces and monastic ensembles, and their harmonious integration to the cultivated terraced landscape on the slopes of high rocky hills. The Natural and Cultural-Historical Region of Kotor bears unique testimony to the exceptionally important role that it played over centuries in the spreading of Mediterranean cultures into the Balkans.

Parts of Kotor with UN-protected status could complicate any Chinese attempts at asset transfer from default but since our research shows the port itself to be a government-back asset, we included the Port of Kotor in our alternative outcomes analysis.

Figure 3: Cargo ship (note cranes) at Port of Kotor
Google Earth 10/2022

Railways and Railway Depots

There are three main rails, the Belgrade-Bar railway, the Nikšic-Podgorica railway, and the Podgorica-Shkodër, throughout Montenegro. As Figure 5 illustrates, they connect through the capital, Podgorica. These are single-rail, multi-purpose lines, transporting passengers and cargo along the same routes.

While all these lines can transport both cargo and passengers, Figure 6 shows the Nikšic-Podgorica has the added ability to transport bauxite from the mining areas in Nikšic to Podgorica.

The Port of Bar is a critical economic node in Montenegro (Figure 7) with rail spurs connecting it to other major economic and industry categories such as mining and petrochemicals.

Furthermore, as Figure 8 illustrates, the classification yard at the port of Bar, which is a flat yard, has eight receiving tracks where freight cars can be moved and attached to different trains depending on the cargo's final destination. While the number of receiving tracks varies depending on the available space, Montenegro's eight receiving tracks for the classification yard make it comparable in size to classification yards in Serbia and Bosnia and Herzegovina.

However, as the image in Figure 8 shows, spatial constraints could prevent a large expansion of the rail yard. With this in mind, China's acquisition of Montenegrin railways could benefit the intrastate and interstate movement of commercial goods and materials of interest to China.

Roads

Since the loan's inception between the Exim Bank of China and the Montenegrin government in 2014, the construction of the A1 highway has been slow to progress. The highway is yet to be finished with large segments still under construction according to open reporting from early 2023, volunteer mapping service edits from OpenStreetMap (Figure 9), and commercial imagery from November 2022 (latest available imagery, Figure 10).

According to Radio Free Europe/Radio Liberty reporting, the highway, once completed, will span sixty-three kilometers between Montenegro and Serbia; however, only forty-one kilometers have been completed as of January 2023. Sources such as Euronews report that the project is going to include forty bridges and ninety tunnels. The A1-highway project will improve both commercial and private travel; however, this highway is not fully accessible to the public as shown by imagery and confirmed with open reporting.

In the case of Montenegro defaulting on the debt, China may consider the full acquisition of the A1 highway. Chinese control of this highway would strengthen China's economic influence in the region. While the government of Montenegro lists approximately thirty border crossing checkpoints between its neighboring countries online, China's possible control of the A1 highway would ensure a stable and constant medium for moving goods from Serbia and the greater Balkans region through Montenegro.

Figure 4: Cruise ship at Port of Kotor
Google Earth 9/2022

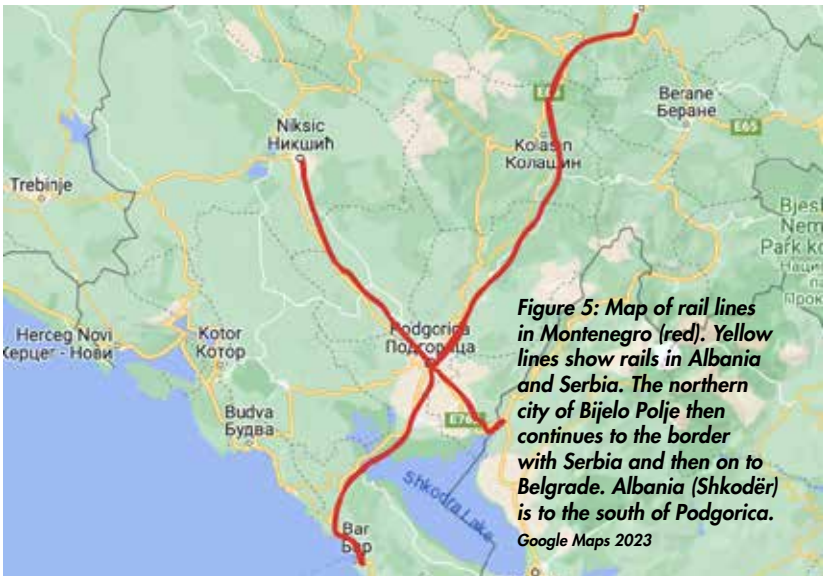


Figure 5: Map of rail lines in Montenegro (red). Yellow lines show rails in Albania and Serbia. The northern city of Bijelo Polje then continues to the border with Serbia and then on to Belgrade. Albania (Shkodër) is to the south of Podgorica.
Google Maps 2023

Figure 6: Bauxite transportation
Google Earth 10/2022

Figure 7: Rail lines traversing through the Port of Bar
Copyright MAXAR 2023/03/28

Figure 8: Port of Bar Classification Yard
Google Maps 03/2023

Furthermore, if China were to acquire this highway it would have a sizable transport asset in a NATO country. Controlling a major transportation artery could be leveraged by China to assist Russia. In 2022, China and Russia stated they have a "no limits" relationship. Russian scenarios are central to NATO's strategic thinking.

Airports

The Montenegrin government currently owns and operates seven airports: Podgorica (TGD), Tivat, and the Berane Airport (BFE) are some of the most active and well-maintained, which would make them the most desirable from a Chinese perspective if a BRI loan default were to occur.

Situated near the capital of Montenegro, the Podgorica Airport's size and passenger activity marks it as the largest in the country. The Podgorica airport accommodates large aircraft and substantial air travel with two large runways, one measuring 8,200 feet and the other at 7,200 feet. Besides commercial travel, imagery analysis shows the open storage of military aircraft (Figure 11). Podgorica, also known as Golubovci Airbase, is a dual-use facility. The BRI loan states that military facilities and lands are exempt from transfer but the dual-use nature of Podgorica with the commercial side of the airport as the primary focus could create a gray area of transfer to China where partial military activity is present.

Tivat Airport, with facilities similar to the Podgorica airport (see Figure 12), benefits from its proximity to vacation and tourist destinations such as Porto Montenegro, according to TripAdvisor. According to the National Tourism Organization of Montenegro, fluctuating tourist traffic, which increases in June, peaks in August, and tapers out in September, presents an opportunity to increase cargo transportation during the winter months.

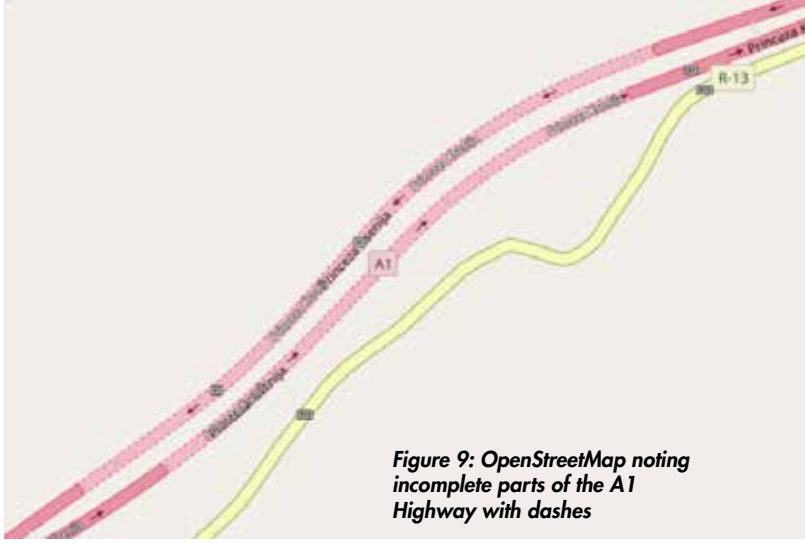


Figure 9: OpenStreetMap noting incomplete parts of the A1 Highway with dashes

Berane Airport, which is currently a general aviation airport, in early 2023 Montenegro signed a memorandum of cooperation with Maik Steinmüller, the founder and CEO of Elite Private Jet Service. This memorandum of cooperation contains the promise of forty-five million euros to revitalize the airport and an additional thirty million euros to work on nano-solar technology within the airport. This investment to modernize the current airport terminal and improve power technology could significantly improve the Berane airport and its commercial aviation capabilities. The Montenegrin government's interest in modernization and expanding airport services beyond passenger travel could interest China. However, the facilities at the Berane Airport, such as its single runway measuring 6,200 ft, its small terminal, and its lack of covered hangers for planes, may take years to improve even with the investment from Maik Steinmüller and Elite Private Jet Service, making the Berane airport a modest object of acquisition by China but with expansion potential (Figure 13).

The focus and infrastructure for all three airports are currently oriented toward passenger traffic rather than bulk cargo operations. However, the commercial advantage gained through controlling a nation's airports, especially a dual-use airport such as Podgorica, may be advantageous for possible Chinese acquisition.

Figure 11: Podgorica Airport
Google Earth 11/2022

Figure 10: Gap in A1 Highway
Copyright Maxar 11/25/2022

Figure 12: Tivat Airport
Google Earth 10/2022.

Note the airport's proximity to the tourism industry. Also, the Port of Kotor is approximately 5 km to the East.

BAUXITE MINES

Montenegro's top-grossing industries are metallic ore exploitation and refinement, with the country's top exports being copper and raw aluminum, according to The Observatory of Economic Complexity, a data visualization site for international trade data. Specifically, the 2019 Minerals Yearbook from the United States Geological Survey states that Montenegro's annual capacity for producing aluminum ore, bauxite, is 1,000 metric tons, making it the country's second-largest export, according to the Observatory of Economic Complexity. Bauxite has been found across Montenegro, with the largest concentration in the Niksic municipality. Currently, mining firm UNIPROM Metali DOO Niksic, a privately-owned Montenegrin company, performs most of the exploitation and processing of this ore in the Niksic municipality.

While the China-Montenegro loan agreement does not directly state or imply China can acquire privately owned property in the case of a loan default, acquiring government-backed rail lines and highways surrounding and servicing the mines could affect (positively or negatively) the flow of bauxite via Chinese-controlled transportation infrastructure. Since 2002, China's reliance on global bauxite imports has steadily increased, reaching 125 million tons in 2022. The Observatory of Economic Complexity states that China is one of the top consumers of Montenegrin bauxite, with approximately 2.7 million USD exported to China in 2021. More simply, the bauxite mines themselves are not at risk of Chinese acquisition from potential debt default; however, based on China's bauxite consumption trends, China could indirectly assert leverage over Nicksic mining via asset transfer of Montenegrin rail lines and highways, which are state-backed assets (Figure 14).

ENERGY INFRASTRUCTURE

China is known for investing in fossil fuel projects designed to bolster its economy and expand its foreign influence. However, China has recently supplemented these foreign fossil fuel ventures with green energy projects. China's *Made in China 2025* plan called for enhancing "green and lean manufacturing capabilities" and reducing "the consumption of fossil fuels." President Xi Jinping pledged, in 2021, not to invest any more funds into coal plants overseas. This declaration, while of questionable long-term validity, illustrates an interest in greener energy alternatives.

Along with this 2021 promise, China unveiled its "Green Silk Road" plan in 2022 to make the Belt and Road initiative more environmentally conscious. Examples of the "Green Silk Road" can be seen in a 2023 Chinese investment in a wind power plant in Luderitz, Namibia. An announcement for a floating solar power plant over the Kariba Dam in Zimbabwe also aligns with China's declared green energy efforts. Montenegro's primary sources of electricity come from hydro-power plants, which presents an opportunity for China to expand its economic interests and influence abroad through the acquisition of Montenegro's "green" energy infrastructure (not coal).

Elektroprivreda Crne Gore AD (EPCG) is a state-owned (heavily government-backed) energy producer in Montenegro. The Montenegrin government owns approximately 90% of EPCG's shares. However, from 2021 to 2022, there has been a decline in EPCG profits from $53.2 million to $4.4 million. Along with declining revenue during this time, EPCG has also faced an increase in operating costs. However, future "green" investments could turn things around financially. Montenegro utility officials publicly stated that new construction projects, such as the Komarnica Hydro power plant, are expected to begin in 2023, along with a wind farm in Gvozd, Montenegro, that is expected to start operations in 2023.

A possible acquisition of Hydro Power Plant (HPP) Piva or HPP Perucica, two major Montenegrin power plants, by China would align with China's "greener" aspirations. Green and/or renewable energy investments often generate positive press. In addition to publicity, the opportunity to own a large share of Montenegro's energy portfolio from power plant acquisitions would substantially

Figure 13: Berane Airport
Google Earth 7/2020. This exemplar image is from 2020 but little construction activity has been observed in more recent imagery from 2023

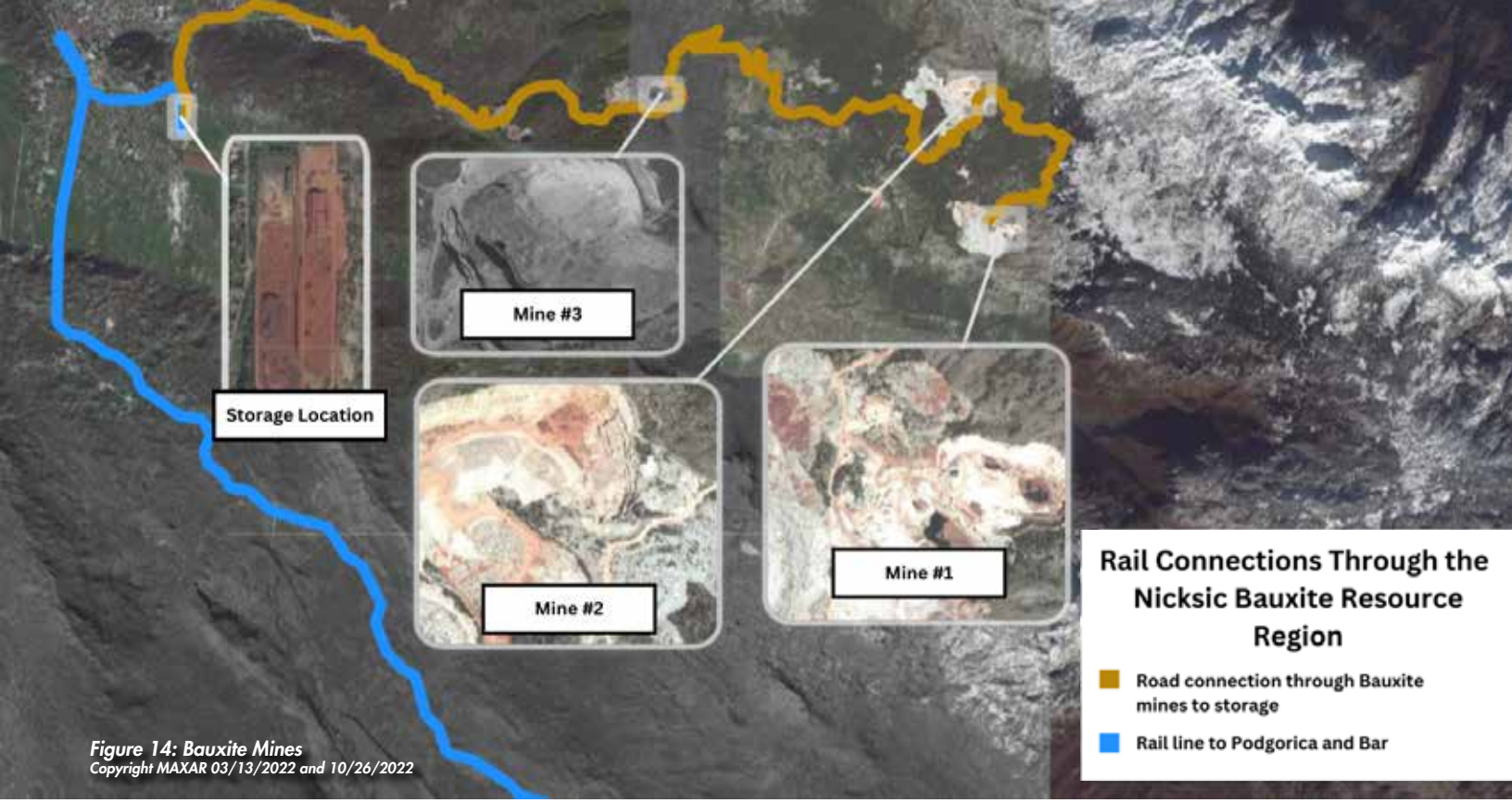


Figure 14: Bauxite Mines
Copyright MAXAR 03/13/2022 and 10/26/2022

benefit the Chinese. According to the EPCG website, HPP Piva accounted for 28.50% of the country's electric energy production in 2018. According to the same website, HPP Perucica made up a larger percentage, accounting for 30% of electric energy production the same year. Therefore, acquiring either plant would transfer almost a third of Montenegro's electric energy production to China. If both were transferred, approximately 60% of the market would be under Chinese interests.

The acquisition of the Pljevlja coal-fired thermal power plant could also be an appealing choice for a possible loan default. Pljevlja is not "green" per se, but China and Montenegro entered into a deal to revamp Pljevlja and reduce emissions. Reuters reported that this project between Montenegro's EPCG and the Chinese company, Dongfang Electric International Corporation, would begin in 2022. However, no subsequent news about the project has been reported. The revenue China would receive from Pljevelja's electrical production would likely be more significant than either HPP Piva's or HPP Perucica's due to the plant's larger output. According to EPCG's website, in 2018, the Pljevlja power plant accounted for 41.40% of Montenegro's energy production.

In addition to the coal-fired plant, Rudnik uglja Pljevlja is a supporting coal mining operation near the plant that would also be an appealing choice for Chinese acquisition (Figure 15). According to Rudnik uglja Pljevlja's website, 100% of the enterprise is backed by EPCG. As mentioned above, approximately 90% of EPCG shares are owned by the Montenegrin government.

Similarly, the Gvozd wind power park could be another enticing option for Chinese acquisition from loan default. The wind park aligns with China's green energy promise, thus acquiring it would likely positively boost China's public image for upholding its promise. Furthermore, acquiring the wind park could also provide an economic benefit. Even though the wind park falls below both HPP Piva and HPP Perucica in electrical production at 54 MW, the positive global press that could result from acquiring a wind power park and the influence China would gain through having a hand in Montenegro's energy portfolio makes the Gvozd wind park desirable.

Figure 15: Pljevlja coal-fired plant and supporting coal mine
Google Earth 7/2020. This is an exemplar image.
More current imagery from 2023 shows this plant and mine are highly active

Russia's Arctic Dilemma: Permafrost Thaw Threatens Russia's Ambitions

In partnership with Johns Hopkins University and written by Chris Johnson

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

OVERVIEW

Climate change in the Arctic is impacting Russia's Arctic plans. As temperatures rise, thawing permafrost has increased the cost of repairs to existing facilities and infrastructure, especially runways. The rate of construction of new facilities more suited to the changing climate situation has also increased Russia's expenditures, which impacts the execution of their strategy.

ACTIVITY

According to GEOINT analysis of 34 Russian airfields in the Arctic, 41% of sites in this study were observed to be under some type of repair, 79% currently present indicators of damage to airfield surfaces, and 29% have been either abandoned or repurposed as something other than a usable airfield.

OVERVIEW

Imagery analysis has identified indicators of environmental damage to Russian airfield infrastructure built on permafrost within the Arctic Circle, as well as indicators of repair activities required to maintain the functionality of the airfields. The annual increase in warming of the region compared to the global average will likely require significant investment in airfield infrastructure maintenance and new construction techniques. These techniques should be more resilient against the threat of permafrost thawing at an accelerated rate.

Russia must engage in regular upkeep of existing airfields and robust construction of new ones to take advantage of its strategic posture in the Arctic. This analysis has identified significant shortcomings towards this effort and a systemic level of impact across airfields in the Russian Arctic. This report provides a background on Russia's Arctic ambitions and a brief explanation of permafrost. It then follows an indicator-centric approach to identify permafrost, damages to infrastructure, and evidence of repairs. A target-centric application of these indicators is applied to a case study focused on Tiksi Airbase, and the report concludes with recommendations for future analysis related to these topics.

The table below lists the Russian Arctic airfields that were the focus of imagery analysis for this report, in descending order of latitude. The list was adapted from the National Geospatial-Intelligence Agency's 2017 Arctic Open Data Portal; known additions were included based on open-source research. The assessments made in the table are best judgments based on imagery analysis and open-source research and are based on the suitability of each airfield for fixed-wing operations. Airfields in bold are referenced explicitly in this report due to their illustrative examples of indicators of interest, but this report is not meant to be an exhaustive compilation of all indicators at all sites.

	Airfield	Latitude	Longitude	Type	Active	Under Repair	Observable Damage	Abandoned	Repurposed
2	**Nagurskoye**	80.8000	47.6583	MILITARY					
3	**Temp Airbase**	75.7627	137.56475	MILITARY					
4	Dikson	73.51776	80.37863	Other					
5	Khatanga	71.97841	102.49319	CIVIL					
6	**Tiksi**	71.69631	128.90226	MILITARY					
7	**Rogachyovo**	71.61711	52.47777	MILITARY					
8	**Sabetta**	71.21444	72.03892	CIVIL					
9	Chokurdakh	70.6247	147.89654	Other					
10	**Pevek**	69.78328	170.59701	CIVIL					
11	**Amderma**	69.76338	61.56243	JOINT					
12	**Dudinka**	69.37439	86.15503	Other					
13	**Alykel/Norilsk**	69.31111	87.33194	CIVIL					
14	**Severomorsk**	69.03256	33.41932	MILITARY					
15	**Severomorsk-2**	69.01453	33.29278	MILITARY					
16	**Mys Shmidta**	68.86858	-179.37534	JOINT					
17	Severomorsk 3	68.86688	33.71929	MILITARY					
18	Murmansk	68.7818	32.75124	CIVIL					
19	Taybola Northwest	68.50754	33.28947	Other					
20	Olenegorsk	68.15172	33.46431	MILITARY					
21	Gremikha S. East	68.03124	39.53449	Other					
22	**Monchegorsk**	67.98895	33.01853	MILITARY					
23	Yepoko	67.98827	75.09705	MILITARY					
24	Kirovsk	67.6449	33.6889	Other					
25	**Naryan Mar East**	67.64028	53.12122	JOINT					
26	Umbozero	67.5161	34.30998	Other					
27	**Vorkuta**	67.48889	63.99294	JOINT					
28	Igarka	67.4686	86.5819	CIVIL					
29	Vorkuta East	67.46452	64.30687	Other					
30	**Kirovsk S. Apatity**	67.4630	33.5880	CIVIL					
31	Alakurtti	66.9609	30.3478	MILITARY					
32	Svetlogorsk	66.84031	88.40281	Other					
33	**Salekhard**	66.5356	66.6106	CIVIL					
34	**Novy Urengoy**	66.0714	76.5200	CIVIL					
35	**Anadyr Ugolny***	64.7347	177.7419	JOINT					

Figure 1: Russian Arctic Airfields of Interest *Anadyr Ugolny was included in the study despite its location slightly below the Arctic Circle due to its useful permafrost indicators. *Source, Original Work by Author*

RUSSIA'S ARCTIC DILEMMA

The increased warming of the Arctic presents both an opportunity and a challenge for Russian strategic military and economic interests. Decreased sea ice extent in the Arctic is expected to make the Northern Sea Route (NSR) and the Transpolar Sea Route (TSR) commercially lucrative economic corridors for Russia, but the associated permafrost thaw creates challenges in the maintenance of existing airfields and the construction of new ones to support economic and military activities in the region. According to the European Space Agency, climate change could result in an Arctic Sea free from summer ice by 2050, allowing longer shipping seasons along the NSR and TSR. Although Russia has the advantage of owning 53% of the Arctic coastline, it must predict and address the risks posed by thawing permafrost to capitalize on its position. The same rapid increase in average temperature that is making the NSR, and eventually the TSR, a more viable shipping route is also destabilizing the permafrost-rich ground on which infrastructure must be maintained for Russia to capitalize on its geographically advantageous position in the region. Figure 2 illustrates that Russian Arctic airfields are generally evenly distributed along the Arctic coast but with a heavier concentration in the West.

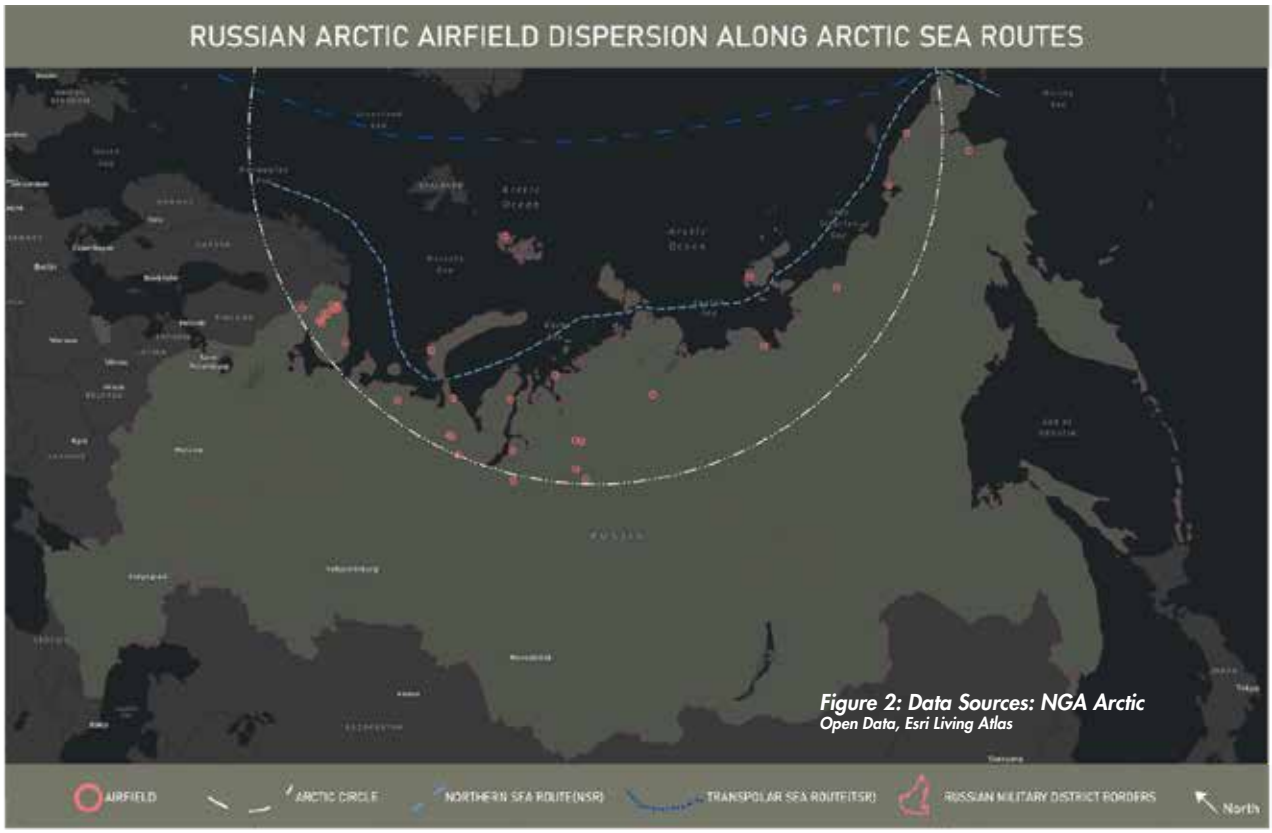


Figure 2: Data Sources: NGA Arctic Open Data, Esri Living Atlas

In 2008, Russian President Dmitri Medvedev adopted a policy that laid out the federation's interests, objectives, and strategic priorities in the Arctic until 2020.

> ***"… it is necessary to carry out a complex building up of competitive advantages of the Arctic zone of the Russian Federation with a view of strengthening positions of Russia in the Arctic, consolidation of international security, maintenance of the peace and stability in the Arctic region."***

Statements in this policy regarding the bolstering of infrastructure against climate change do not explicitly mention thawing permafrost as the leading factor in this threat, but the language used implies that unstable ground is a primary concern that needs to be addressed for Russia to take advantage of its strategic positions in the Arctic.

> ***"…forecast and estimation of consequences of global climatic changes occurring in the Arctic zone Russian Federations under the influence of natural and anthropogenous (sic) factors, in intermediate term and long-term prospect, including an increase of stability of objects of the infrastructure…"***

On 05 March 2020, Russian President Vladimir Putin adopted a continuation of Medvedev's Arctic policy, "Foundations of the Russian Federation State Policy in the Arctic for the Period up to 2035". Though the policy largely follows the format and content of previous Russian and Soviet Arctic policies, it does contain slightly stronger language regarding the importance of the NSR to Russia's economic health and the threats posed to infrastructure by climate change. The policy states that the implementation of Russia's strategic aims in the Arctic is in direct support of overarching national priorities:

> ***"e) developing the Northern Sea Route as the Russian Federation's competitive national transportation passage in the world market;"***

The word "permafrost" does not appear in this policy. Yet, there is a clear emphasis on the need to adapt or develop science and engineering solutions that are resilient against climate change.

> ***"c) to increase research on natural hazards and man-made hazardous activities in the Arctic, and develop and implement modern methods and technologies for predicting these effects in a changing environment, as well as methods and technologies to reduce threats to human life;***
>
> ***d) to develop and implement practical engineering solutions to prevent damage to infrastructure components due to global climate change…"***

Russia's adopted strategic plans for the Arctic are ambitious and a high priority for their near- and long-term focus, but official government policies only indirectly address the threat posed to these interests by thawing permafrost. Arguably the most notable and public disaster in the Russian Arctic that has been attributed to the degradation of infrastructure due to thawing permafrost is the 2020 Norilsk Nickel diesel tank leak. This disaster led President Putin to declare a state of emergency and to order inspections of other "particularly dangerous installations" in permafrost areas. Investigators attributed the leak to a failure of the diesel storage tank's supports due to thawing permafrost, but the Russian Investigative Committee ultimately charged the power plant's director with negligence. Despite the apparent attempt by the Russian government to place blame on an individual's actions or lack thereof, the Norilsk disaster is likely an indicator of a more systemic issue regarding infrastructure built on permafrost.

Russian Arctic scientists and citizens are more direct when bringing attention to the serious problems that this threat has already uncovered. The town of Churapcha, a Siberian settlement in the Yakutia region, is one of the more glaring examples of airfield failure due to thawing permafrost. In the 1990s, Churapcha's airfield, initially built in the era of Soviet expansion into Arctic territories, was permanently closed as thawing and refreezing permafrost below its surface became too severe to maintain the integrity of the airfield's surface. Today, there is little evidence that the airfield at Churapcha ever existed as seen in Figure 3. The former site is now a field of clearly visible ice wedge patterning, a familiar terrain in much of the Russian Arctic. According to Alexander Fyodorov, deputy director of the Melnikov Permafrost Institute of the Siberian Branch of the Russian Academy of Sciences, 72% of residents surveyed in the Yakutia region reported problems with the stability of their homes' foundations, suggesting that the threat to infrastructure from thawing permafrost is widespread throughout the Russian Arctic.

"There isn't a single settlement in Russia's Arctic where you wouldn't find a destroyed or deformed building."
Alexey Maslakov, Moscow State University

PERMAFROST OVERVIEW

Basic understandings of permafrost's definition, extent in the Russian Arctic, and visible signatures of its presence are necessary to observe its effects on infrastructure. The first scientific studies of "permanent frost" were published in the 1830s by the Royal Geographical Society of London following a study of the thickness of frozen ground in Yakutsk, Russia, but the word "permafrost" was not adopted until over a century later during the construction of the Alaska Highway12. Today, permafrost is defined by the National Snow and Ice Data Center (NSIDC) as:

"…a layer of soil or rock, at some depth beneath the surface, in which the temperature has been continuously below 0°C for at least several years; it exists where summer heating fails to reach the base of the layer of frozen ground."

This general definition over arches two subcategories of permafrost: continuous and discontinuous. As the name implies, an area with continuous permafrost contains uninterrupted permafrost coverage beneath the surface, whereas discontinuous permafrost signifies an area containing pockets of permafrost amongst areas with no permafrost. The below map shows that nearly all Russian airfields within the Arctic Circle have been built atop permafrost to some extent.

As Arctic temperatures continue to increase, thawing the permafrost layer to deeper depths, formerly solid ground held together by ice will become a fluid mass with the potential to wreak havoc on infrastructure built on the surface. Since the 1960s, some Russian Arctic cities have already seen a decrease in the ground's load-bearing capacity by more than 40%15. Despite the difficulty in assessing whether a specific site has been built on continuous or discontinuous permafrost from satellite imagery, several visible indicators of permafrost thaw can assist in determining the severity of local ground destabilization. Ice wedges and thermokarst features are two common indicators of permafrost presence most useful for imagery analysis.

Figure 3: Churapcha airfield site
Google Earth 2021/06/13

Figure 4: *Data Sources: NGA, Esri Living Atlas, Arctic Permafrost Geospatial Center*

PERMAFROST INDICATORS

Ice Wedges

NSIDC defines an ice wedge as "a narrow ice mass that is 3 to 4 meters (10 to 13 feet) wide at the ground surface, and extends as much as 10 meters (33 feet) down; a decrease in temperature during the winter leads to ice wedge cracks in the ground around ice wedges; during the summer, these cracks accumulate melt-water and sediment, forming pseudomorphs."

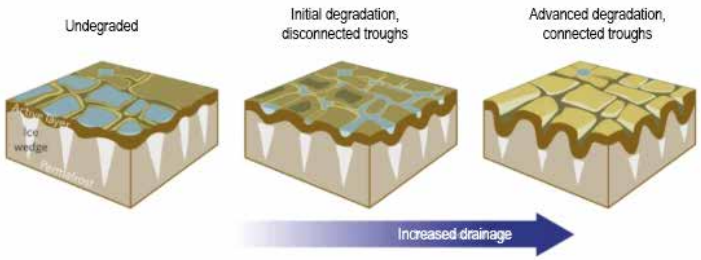


Figure 7: Ice wedges at Tiksi
Copyright MAXAR 08/16/2022

Figures 5 and 6 show the degradation of ice wedge patterning over time and a cross-section view of an ice wedge, respectively

Figure 5. Ice Wedge degradation. Adapted from "Pan-Arctic ice-wedge degradation in warming permafrost and its influence on tundra hydrology", Although ice wedges exist below the surface, their presence can be easily detected in satellite imagery by the distinctive polygonal patterning created on the surface as seen in Figures 7 to 12. Ice wedges shrink year over year as the permafrost continues to warm, leaving meltwater and troughs in their place. This evolution is important regarding threats to nearby infrastructure because ice-wedge degradation changes the hydrology in the surrounding area; this results in increased runoff of surface water with the potential to erode and destabilize foundations of buildings and airfields, buckle roads and railways, and cause the failure of the support pilings of above-ground gas and oil pipelines.

Thermokarst Features

Thermokarst features are another familiar sight on the landscape of the Russian Arctic. Thermokarst is defined by NSIDC as: "the process by which characteristic landforms result from the thawing of ice-rich permafrost or the melting of massive ice."

The definition of thermokarst is broad, and the phenomenon can manifest itself in various ways but is most easily observed on satellite imagery when a depression forms that has collected water. The presence of thermokarst lakes, ponds, and smaller pockets of standing water suggests that large portions of permafrost in the area no longer remain completely frozen in consecutive seasons. Though melting ice wedges can play a part in thermokarst feature formation, their development typically involves large-scale thawing of permafrost as well. The thermokarst process can create a feedback loop wherein thermokarst feature formation is followed by an even more rapid ice melting and permafrost thawing in the area. Figures 14 through 18 are illustrative of the varying visual indicators of thermokarst lakes and ponds.

While larger thermokarst features like lakes and ponds can be associated with natural processes, imagery analysis has identified a trend of smaller thermokarst feature development directly adjacent to human activities such as excavation, construction, and routine activities. These smaller thermokarst features resulting from human activity can be identified by their irregular shapes as compared to thermokarst lakes; often, their shapes follow airfield drainage lines, artificial embankments, and building footprints. Figures 19 through 24 demonstrate examples of thermokarst feature development adjacent to human activity.

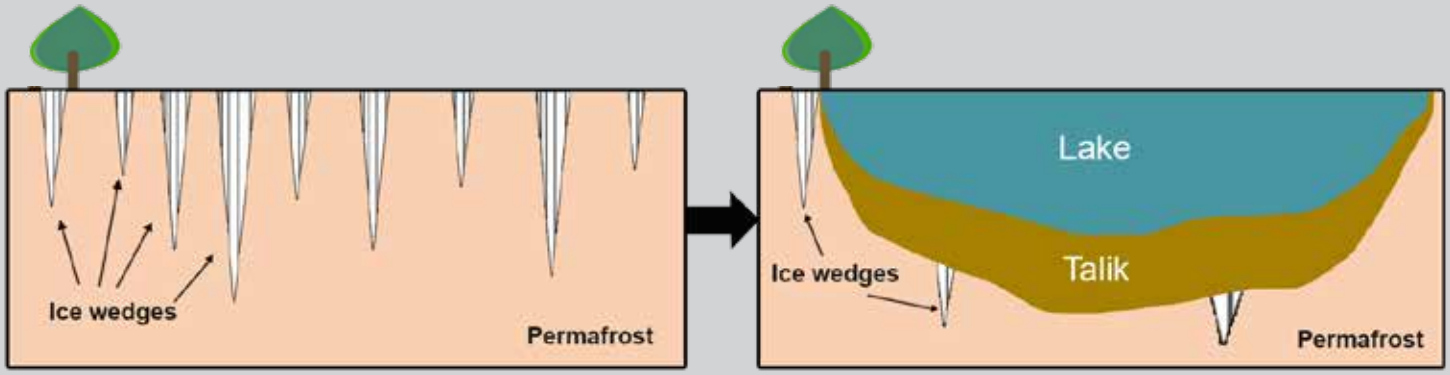


Figure 13: Diagram of thermokarst lake formation. Adapted from "Biogeochemistry of Permafrost Thermokarst Lakes in the Canadian Subarctic"

Figure 14: Large thermokarst lakes west of Rogachovo
Google Earth 2022/07/15

Figure 19: Small thermokarst features at Tiksi
Copyright MAXAR 2022/08/16

PERMAFROST INDICATORS

Conclusion

Ice wedges and thermokarst features are two visible indicators of thawing permafrost, but it should be noted that their direct effects on nearby infrastructure can be difficult to ascertain from imagery analysis alone. The temporal and spatial resolution of electro-optical satellite imagery products are adequate to track incremental changes to permafrost indicators from year-to-year or season to season, but as the thawing continues to increase rapidly, abrupt permafrost thaw events have the potential to impart significant damage to infrastructure in a short period of time depending on local conditions at a specific site. Despite the challenges of predicting location-specific permafrost impacts to infrastructure, imagery analysis has identified a trend of permafrost-related damage to airfields and their surrounding infrastructure within the Russian Arctic.

INDICATORS OF DAMAGE

A rudimentary explanation of Russian airfield construction, which today is an evolution of Soviet techniques, is helpful in understanding indicators of airfield damage and their implications. A unique aspect of Russian airfield construction in the Arctic is the use of pre-cast, pre-stressed concrete slabs, which are welded together in place after being leveled atop a foundation generally made of sand, gravel, and crushed concrete which serves to insulate the surface from unstable ground and is necessary to increase the load-bearing capacity of the slab surface above. An example of concrete airfield slabs and the welding technique used to secure them is provided in Figure 25. The portability of prefabricated concrete slabs made off-site makes them advantageous for use in the harsh and remote Arctic terrain; airfield slabs can be transported from concrete factories by land, sea, or air in batches for new airfield construction and for repairs as required.

Proper drainage design is another component of Russian Arctic airfield construction which comes with unique considerations given the challenging nature of building above permafrost; Russian building codes for aerodromes provide guidance for creating drainage structures based on the unique hydrological and climatic characteristics of a specific site but does not offer precise requirements beyond stating that it is "necessary to provide measures aimed at preventing the occurrence and activation (of) thermokarst, thermal erosion, thermal abrasion, heaving, frost cracking, solifluction, ice formation, and other cryogenic processes". Imagery analysis has identified damage to drainage structures and the secondary effects of this damage on other features of airfields, likely due to changes in local hydrology and surface stability caused by thawing permafrost since initial construction. Figure 26 uses Rogachovo airfield to illustrate an overview of common Russian airfield construction components.

Figure 25:
Prefabricated concrete slabs (left) and welded joint (right). Adapted from Damage to Russian Arctic airfields and their supporting infrastructures poses a direct threat to Russia's ability to project power and capitalize on economic opportunities in the region. Airfield surfaces and foundations, drainage features, and supporting facilities like fuel storage depots are all critical to the safe and effective functioning of an airfield. These airfield features are also all at risk of damage due to the unstable ground created by thawing permafrost.
https://www.researchgate.&/#65279;net/publication/347228859_Reconstruction_of_the_Technical_Condition_of_Concrete_Airfield_Pavements_with_the_Use_of_Prefabricated_Slab_Technology

Airfield Surfaces and Foundations

The unique construction characteristics of Russian Arctic airfields present an opportunity for imagery analysts to identify surface damage indicators in two main categories. First, satellite imagery can show both horizontal and vertical dispersion between adjacent slabs. A significant enough difference in the spacing or vertical disparity of adjacent slabs in key areas of the airfield surface can render the airfield unusable if allowed to reach critical levels. Second, the degradation of individual slabs can be observed in the form of crumbling and cracking patterns. Both indicators are prevalent in all Russian Arctic airfields that were originally built in the Soviet era.

Runway touchdown zones (TDZs) are the "…point at which an aircraft first makes contact with the landing surface…" and are susceptible to the greatest vertical forces and are common areas showing indicators of damage to the airfield surface. At Rogachovo Air Base, distinct discoloration between concrete slabs within the TDZ is visible in Figures 27 and 28 and seems to suggest some degradation in the integrity of the surface.

Similar indicators of airfield surface damage are evident on parking aprons; Rogachovo and Naryan Mar are two locations with strong visual indicators of such damage as seen in Figures 29 and 30. Areas showing damage to the apron surface are consistent with what would be expected from recurring increased temperatures proximate to jet exhaust; this indicator suggests subsidence due to thermokarst processes or direct damage to the structural integrity of slab welds. This evidence shows that thermal impacts, as well as direct mechanical forces, have the potential to degrade airfield surfaces.

Indicators of damage to airfield surfaces resulting from abandonment or failure to perform routine maintenance of concrete slabs are also evident and can serve as a baseline for environmental effects over time. Severomorsk-2 is one example with indicators of surface damage in the form of slab separation and vegetation growth. This site is a particularly good example of long-term damage indicators, as hexagonal slabs, which were likely used for original construction in the 1930s, are visible alongside more recent rectangular slab additions to the airfield surface and surrounding areas. Both the hexagonal and rectangular slabs show visible indicators of increased separation and vegetation growth between adjacent slabs. Severomorsk-2 is also unique in that a new section of the runway was paved onsite, rather than constructed with concrete slabs, between August and October of 2016; the paved sections of the airfield already show significant indicators of cracking and subsidence. Figures 31 through 39 show the prevalence of this type of damage at airfields across the Russian Arctic.

Figure 27: North end Rogachovo airfield, *Google Earth 07/15/2022*

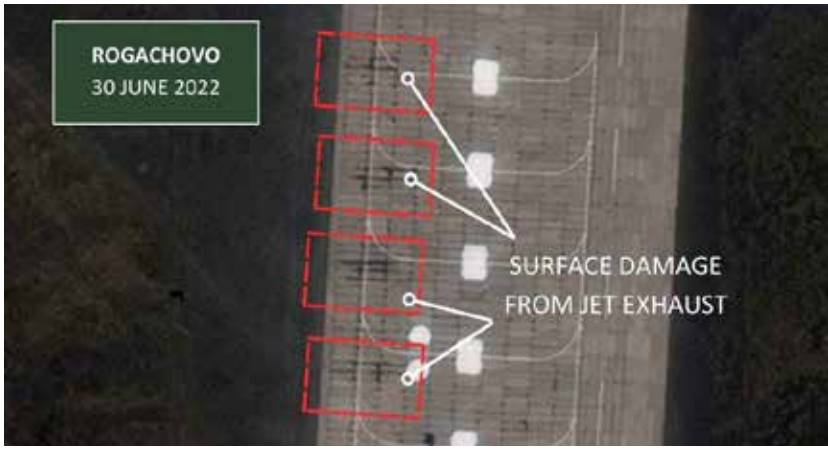


Figure 29: Parking apron damage proximate to jet exhaust
Copyright MAXAR 06/30/2022

Figure 31: Damage to 1930s-era hexagonal slabs, *Google Earth 08/24/2022*

Figure 40: Anadyr Ugolny overview
Google Earth 08/19/2022

SUPPORTING INFRASTRUCTURE

Russian Arctic airfields possess varying levels of local infrastructure related to their effective operation. In general, more remote airfields located at higher latitudes operate with a minimum of supporting infrastructure, such as fuel storage and distribution, command and control facilities, and limited aircraft maintenance support. Airfields collocated with industrial activities, such as resource mining or natural gas extraction, often have more robust supporting infrastructures required to carry out such activities and to support a local population. Imagery analysis has identified permafrost-related damage to supporting infrastructure at Russian Arctic airfields, the most extreme examples of which have resulted in the complete abandonment of infrastructure built on affected tracts of land.

Anadyr Ugolny Airport, located in Russia's Far East, is a prime example of the extent to which permafrost thaw can damage infrastructure beyond what is reasonable to repair or repurpose. The west side of Anadyr Ugolny airfield, originally built in the 1950s as a strategic deployment base for long-range bombers, stands in stark contrast to the modern infrastructure which has been built on the east side of the airfield to support civil flights. The original airfield infrastructure and neighboring settlement, known as "Coal Mines", show extensive indicators of damage due to thawing permafrost. User-provided commentary of the village on Wikimapia suggests that the area was officially ordered to be resettled in 2014, yet a handful of hearty residents remain. Figure 40 demonstrates the impact of permafrost on infrastructure at Anadyr Ugolny; critical infrastructure from the original airfield and settlement has largely been abandoned in favor of new construction atop ground with less visible indicators of permafrost presence.

Modern fuel storage facilities have been built at Anadyr Ugolny, but damage to the Soviet-era fuel storage facilities in the area paints a concerning picture for the potential future of any infrastructure built on thawing permafrost. Four Soviet-era fuel storage sites dispersed along the west side of the airfield all present significant indicators of damage induced by thawing permafrost and associated thermokarst processes. Although these fuel storage sites are no longer necessary for the operation of Anadyr Ugolny, the disaster at Norilsk should serve as a warning that similarly constructed infrastructure is at risk of causing serious environmental damage if any fuel remains in the tanks. Figures 41 to 44 show a concerning pattern of thermokarst related deterioration of fuel tanks at Anadyr Ugolny.

Figure 41: Fuel storage near the river
Google Earth 08/19/2020

Damage to buildings at Anadyr Ugolny is extensive and at varying levels of severity. In general, buildings closer to obvious indicators of permafrost have fared worse over time. The former village known as "Coal Mine" is a mix of residential and industrial buildings, some of which are in complete ruin, and it presents numerous indicators of damage from thawing permafrost as seen in Figure 45.

Figure 45: "Coal Mine" village
Google Earth 08/19/2022

Outside of the former village itself, abandoned Soviet-era military infrastructure has fared poorly over time in the face of encroaching thermokarst features. One such example is the former site of "Unit 60082", an anti-air defense unit that operated in support of the airfield. Figure 46 is an approximation of the footprint of the former military facility based on the presence of human-caused thermokarst indicators combined with open-source research.

Figure 46: Former site of "Unit 60082"
Google Earth 08/19/2020

Despite the obvious and extensive damage to infrastructure at Anadyr Ugolny and many other Russian Arctic airfields, it can be difficult to ascribe the damage to permafrost thaw with satellite imagery analysis alone. Open-source, user-provided images of Anadyr Ugolny and other sites can help demonstrate the extent to which subsidence of the ground is detrimental to the structural integrity of critical infrastructure, including energy delivery, communication lines, and buildings. Figures 47 through 50 provide ground-level examples of thermokarst features that are also visible from satellite imagery.

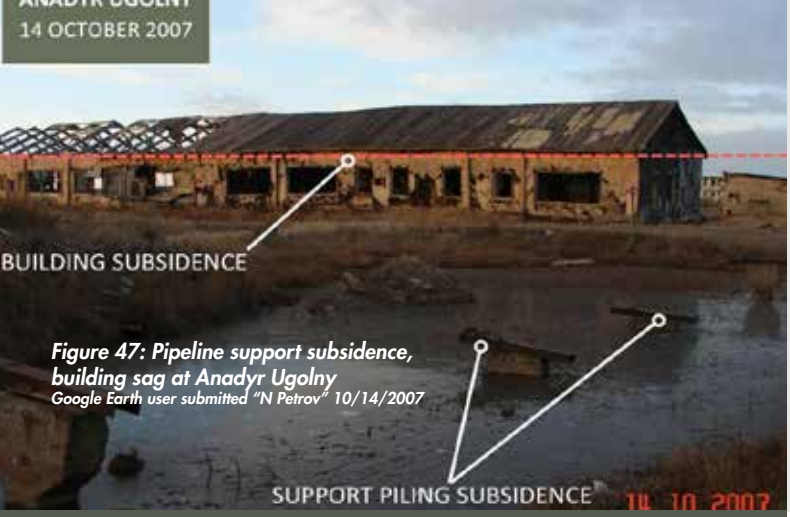


Figure 47: Pipeline support subsidence, building sag at Anadyr Ugolny
Google Earth user submitted "N Petrov" 10/14/2007

Damage Indicators Conclusion

Indicators of damage at Russian Arctic airfields demonstrate a perpetual and extensive challenge to their continued operation; the non-exhaustive examples above are indicative of the current extent of the problem as well as a possible preview of what is to come, even at sites that do not currently show serious indications of damage. As climate change causes permafrost to thaw more rapidly, changes to local hydrology are likely to outpace original design efforts to manage their effects on airfield surfaces and supporting infrastructure. Permafrost-induced damage to Russian Arctic airfield surfaces and supporting infrastructure appears to be outpacing the nation's efforts to anticipate, identify, and address the effects.

INDICATORS OF REPAIRS

Indicators of repairs to airfields are considerably easier to discern in satellite imagery than indicators of permafrost extent and indicators of damage. Imagery analysis has identified that repairs to existing airfields (many from the Soviet era) are completed in an ad-hoc manner. As sections of damaged airfield surfaces are removed and replaced, they offer a large temporal window in which the repair activities can be observed. Similarly, the replacement of large sections of concrete slabs and accompanying equipment entails a large spatial footprint that is easily observable. Onsite repair capabilities can also be observed through satellite imagery as concrete replacement slabs are often stored in the open on parking aprons, aircraft revetments, or nearby ports. As noted from indicators of damage to buildings and other supporting elements of airfields, permafrost thaw can render some infrastructure unusable beyond repair. This level of damage can require new construction to replace the assets in an area that has not yet been fully impacted by permafrost thaw. Additionally, it is useful to observe the construction of new airfields within the Russian Arctic to assess whether new techniques are being employed to combat the threat of permafrost.

Figure 51: Concrete slab staging at Monchegorsk
Google Earth 06/25/2009

Repairs to Existing Airfields

Monchegorsk Airbase, located in Murmansk Oblast on the Kola Peninsula, provides an opportunity to evaluate the airfield repair process from the arrival of materials until the completion of needed repairs. Monchegorsk, a center of copper and nickel mining, is well connected to Russian industrial centers from which concrete slabs are transported. The airfield's nearness to the supply chain of necessary materials for airfield repairs allows it to serve as a measure for repair timelines against the remote and isolated airfields, which are more typical of the Russian Arctic. Despite the relative geographic advantages of Monchegorsk Airbase in comparison to most other Russian Arctic airfields, including minimal severe indicators of permafrost within its fence line, progress in addressing clear indicators of damage has been a slow process.

The first indicator of imminent airfield repairs at Monchegorsk is observable in available satellite imagery in June of 2009 as seen in Figure 51. By this date, a large reserve of concrete slabs has been staged on a parking apron on the west side of the runway. Indicators of damage are present in various areas of the airfield at this time, with the TDZ showing the heaviest signs of use.

In August 2009, the new concrete slab reserves were repositioned to a parking apron and taxiway that is adjacent to the runway near the TDZ as seen in Figure 52. Additional slab reserves also arrived in this two-month window and were staged on the central taxiway of the airfield. While the movement of the first batch of concrete slabs could be interpreted to indicate that repair efforts were imminent, the movement appears to have been necessary to accommodate fighter aircraft parking on the apron. The appearance of replacement slabs during the same summer period in which a significant increase in fixed-wing aircraft also arrived at the base is relevant in that it suggests that repairs were needed to support increased future operations. The arrival of new aircraft to the base in 2009 suggests that the airfield surface was deemed at least functional enough to accept an increase in operational capacity in the short-term, despite equal evidence that repairs were needed soon.

By August 2010, slab reserves were visible at both north and central taxiways while fighters occupied the parking apron on which the slabs were originally delivered.

The first indicators of repairs were evident in July of 2013, nearly four years after the replacement slabs arrived at Monchegorsk Airbase. The replacement of concrete slabs within the TDZ is clearly visible, as is a significant reduction in the available slab reserves.

By May 2014, the entirety of the stockpile from the central taxiway and approximately half of the slabs stored on the north parking apron had been used to complete repairs on the north TDZ. The indicators of recent repairs are clear on satellite imagery thanks to the contrast of the newer, lighter-colored slabs adjacent to those that have not been replaced. The repaired area is also clearly surrounded by an exposed layer of sandy soil, likely from the process of re-grading and leveling the foundation during the repair process. The total length of this repaired runway section measures approximately 370 meters.

Many indicators of damage to the airfield surface remain evident even after the repairs of 2013-2014, but additional replacement slabs do not appear until the summer of 2017. Two years later, in June 2019, the first indicators of additional repair work were apparent in the area directly adjoining the section of previous repairs.

This repair effort was completed by September 2019 with an additional 230 meters of repaired runway, but only the slabs along the centerline were replaced as compared to the total surface replacement of the TDZ in 2014.

Figure 52: Slab stockpile movement to taxiway *Google Earth 08/03/2009*

Figure 53: Slabs in place, aircraft on apron *Google Earth 08/29/2010*

Figure 54: Repairs begin at Monchegorsk *Google Earth 07/25/2013*

Figure 55: Repairs complete at Monchegorsk *Google Earth 05/28/2014*

Figure 56 2019 repairs at Monchegorsk *Google Earth 2019/06/16*

Figure 57: 2019 repairs at Monchegorsk complete *Google Earth 09/01/2019*

Figure 58:
Slab reserves at Monchegorsk 2021
Google Earth 01/27/2021

Figure 59:
2022 repairs complete at Monchegorsk
Google Earth 08/20/2022

By January 2021, a new batch of replacement slabs had arrived on the center taxiway at Monchegorsk.

The next visible indicator of completed repairs occurs in August of 2022 when an additional 300 meters of runway centerline was replaced.

In total, since the first batch of replacement slabs arrived at Monchegorsk in 2009, it took over thirteen years to complete repairs for 900 meters of runway. This slow, piecemeal approach to airfield surface repairs at Monchegorsk is typical of all Russian Arctic airfields which show indicators of repairs, and this trend implies a systemic challenge to their proper upkeep in the face of regular use on top of thawing permafrost. The infrequent delivery of replacement material in small batches appears to dictate the pace of repairs at Monchegorsk, and the conservative decision to replace only the centerline of runway sections beyond the TDZ is evidence that the production of new concrete slabs is unable to keep pace with needed repairs.

Dudinka, a small and remote airfield on the Yenisei River, provides further indicators of delayed or abandoned repair efforts. By May 2013, several sections of the airfield surface were removed, and replacement slabs had been staged for repairs.

Figure 60:
Dudinka staged for repairs
Google Earth 05/15/2013

Figure 61:
No progress at Dudinka
MAXAR 07/15/2022

By the summer of 2022, no indicators of progress on the repairs are evident.

The lack of progress on repairs at Dudinka, despite an apparent desire or need to carry them out, roughly matches the timeline in which repairs at Monchegorsk were heavily delayed. Dudinka's remoteness and lack of strategic and economic importance are likely factors to blame for the apparent abandonment of repair efforts there. Airfields that support industry, military, and civil flights on a regular basis have significantly less tolerance for delayed repairs; a lack of available replacement slabs threatens to significantly disrupt required operations unless an alternative solution is employed. The airfields at Novy Urengoy and Salekhard show indicators of alternative repair methods which utilize traditional paving methods rather than direct slab replacement. It is notable that these two examples reside at the lowest latitudes of all airfields observed in this study; longer summer seasons and higher average temperatures could be a factor in the feasibility of traditional paving methods for sustainable repairs.

In May 2018, an agreement was signed to modernize Novy Urengoy airport by the end of 2021 with no disruption to airport operations. The appearance of Novy Urengoy's airfield surface prior to the start of repairs is typical of a Soviet-era air- field constructed completely of pre-stressed concrete slabs.

Figure 62:
Novy Urengoy prior to modernization
Google Earth 07/05/2017

By July 2021, most of the runway surface was paved over. In comparison to slab replacement repairs, the airfield was resurfaced from the center outwards rather than starting with the TDZs.

By July 2022, the modernization project was behind the stated schedule but close to completion, with indicators of continued paving on parking apron areas.

Figure 63: Paving at Novy Urengoy
Google Earth 07/07/2021

Salekhard Airport also received similar upgrades to the airfield surface between 2005-2007, when the slab surface of the runway was paved in conjunction with changes to the drainage design. These upgrades are clearly visible in Figures 65 and 66.

Indicators of patch-work repairs to the runway with a paving approach are evident as recently as August of 2021.

Figure 64: Modernization continues at Novy Urengoy
Google Earth 07/12/2022

Indicators of repairs across Russian Arctic airfields show a trend of long delays and alternative (even if less than ideal) techniques to address damage. While modular concrete slab airfield design was intended to facilitate rapid repairs, imagery analysis suggests that increasing damage due to thawing permafrost has outpaced Russian production and supply chain capabilities to leverage this advantage. The assessment that the production of replacement slabs is a major roadblock to the proper upkeep of Russian airfields in the Arctic is further bolstered in a statement by the deputy director of construction for Yamal LNG regarding building a new airfield to support a $27 billion liquid natural gas facility in Sabetta, located on the Yamal peninsula. Deputy director Dmitry Monakov stated in 2015, regarding airfield surface construction at Sabetta, that:

> ***"The main problem we faced was that Russian plants have long stopped producing these plates in such industrial volumes. We had to hold a serious competition, and we had to give the winner some time to grow their production capacities before they were able to satisfy our requirements."***

Figure 65 Salekhard surface in 2005
Google Earth 2005/09/07

Sabetta and other recently built airfields within the Russian Arctic provide an opportunity to view adjustments made to the construction process based on lessons learned and a better understanding of the impact of permafrost on infrastructure.

New Construction

The completion of the airfield at Sabetta in 2014 provides an example of adjustments to Russian Arctic airfield design, which can be monitored in the future to measure their resilience against thawing permafrost, ideally limiting the need for repairs. Sabetta will be a particularly tough test of any new design implementations, as it was built atop an area showing severe indicators of permafrost threat. Satellite imagery of the site in 2003 shows extensive thermokarst features and vehicle tracks (likely from initial gas field reconnaissance) left in the soft ground.

Figure 67: Patchwork repairs at Salekhard 2021
Google Earth 08/04/2021

Left with little choice but to build atop this unstable ground to capitalize on the extraction of natural gas, there are some indicators in the design of the airfield and supporting infrastructure that appear to be designed to minimize the need for future repairs. Sabetta's airfield consists of a substantial outer berm, well removed from the edges of the airfield surface, and appears to have a drainage system that routes surface water far away from the perimeter towards an existing thermokarst pond. Notably, pre-stressed concrete slabs have been chosen as the best solution for airfield construction in this environment despite previously mentioned indicators of repairs that employ other techniques.

Figure 68: Sabetta airfield site prior to construction
Google Earth 07/05/2003

The natural gas extraction site at Sabetta, which the airfield supports, entails dramatic industrial activity which can accelerate local warming. Figure 70 shows the port area of the Yamal LNG site, which is only a small percentage of the infrastructure built in the immediate area. Supporting infrastructure has been built atop sandy foundations, some of which display signs of damage and need for repairs before construction was completed as seen in Figure 71.

Figure 69: New design format at Sabetta
Google Earth 08/20/2020

Figure 70:
LNG processing site and port at Sabetta
Google Earth 03/17/2021

Some skepticism regarding the sustained effectiveness of these efforts is warranted, according to Columbia University lecture and energy and marine transport expert Natasha Udensiva:

"I'm not sure how long the project will go on because of climate change. They built the LNG plant on pilings because of the permafrost, and yet everything in the Arctic is melting. In gas fields, in particular there is some danger. There are many holes in the permafrost there already and you don't know when they will open up."

One such example of this danger is already emerging in the form of a thermokarst pond which has rapidly increased in size; the difference is notable when comparing Figure 72 to 73. This pond is encroaching on the foundation for dormitories and currently supports a pipeline that has been routed directly through its center. The change in the size of the thermokarst pond from 2016-2020 is drastic and will provide a formidable test to the strength of the sand foundation as well as the support piling for the pipeline.

Figure 72
Sabetta thermokarst pond 2016
Google Earth 07/06/2016

Sabetta is just one example of several recently constructed or completely overhauled Russian Artic airbases which should be monitored for eventual repairs. Russian Arctic bases in the far north, such as Temp Naval Base and Nagurskoye airfield, are other examples of more modern construction methods employed in harsh conditions with significant indicators of permafrost. The recently built "trefoil" style buildings will be particularly useful to observe for resilience against thawing permafrost; a baseline for needed repairs can be established once the first indicators of repairs arise. The construction similarities between the two sites are visible in Figures 74 and 75.

Indicators of Repairs Conclusion

Russia's ability to repair airfield damage in a timely and sustainable manner lies at the crux of the nation's Arctic dilemma; the ability to produce, transport, and install replacement concrete slabs is crucial to the sustained operation of Russia's network of airfields within the Arctic Circle. Imagery analysis has identified no "on-site" concrete slab production capabilities at these airfields, and other sources suggest that the highest quality concrete slabs are produced near Moscow, St. Petersburg, and other sites within European Russia. The modular design nature of Russian Arctic airfield construction is beneficial in that it allows "piecemeal" repairs only to affected areas versus complete airfield resurfacing, but this concept also demands an efficient supply chain and construction process to minimize airfield downtime. Indicators of alternative methods of repair, such as more traditional paving, are evident but unlikely to provide a long-term solution, particularly at the most remote sites. New airfield construction on permafrost should be monitored for indicators of repairs; this effort would help to establish baselines and determine Russia's ability to successfully adapt construction practices based on lessons learned from challenges faced at Soviet-era airfields within the Arctic Circle.

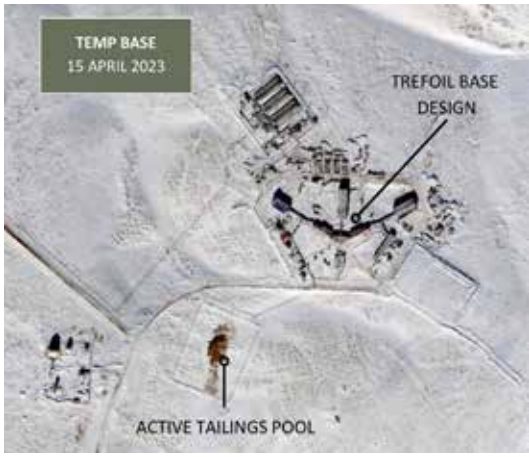


Figure 74:
Trefoil base design at Temp Naval Base
Copyright MAXAR 04/15/2023

CASE STUDY-TIKSI

Previous Tearline reporting published by CSIS in 2019 addressed the significant delays in upgrades to Tiksi Airbase (for the eventual deployment of an S-400 air defense regiment and MiG-31 interceptors) in contradiction to official Russian statements but did not explain the lack of progress beyond possible financial limitations or an attempt at misdirection regarding the true purpose and strategic value of the site37. A target-centric application of permafrost indicators suggests that permafrost-related damages, and a limited supply of replacement slabs, play a significant role in the disparity between official Russian statements on progress at Tiksi as compared to the reality observable in satellite imagery. Evidence of delayed, but still ongoing, repairs to the airfield surface since the CSIS publication in 2019 suggest that Russian ambitions to utilize Tiksi as a MiG-31 staging base remain valid. This suggests that the disprovable Russian statements of progress at Tiksi are meant to avoid a public admittance of the mounting challenges of maintaining airfields that the country faces in the future rather than intended to obfuscate adversaries regarding their intended use of the site. Tiksi has been chosen for a case study application of permafrost-related indicators due to its strategically important location, previous reporting on the site, and because it displays strong examples of each indicator.

Figure 76:
Tiksi Airbase Support Facilities
Google Earth 09/02/2016

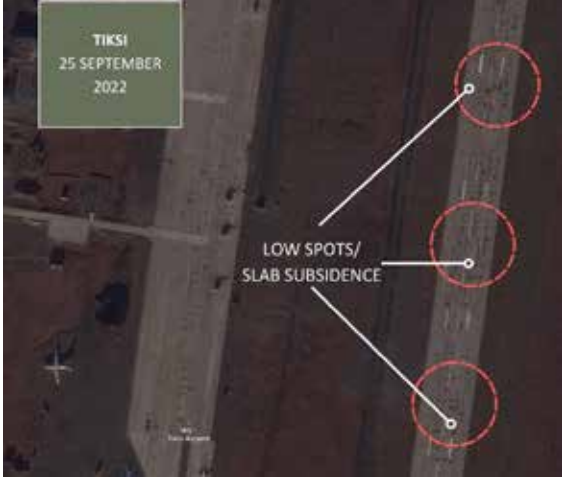


Figure 79:
Low spot indicators at Tiksi
Copyright MAXAR 09/25/2022

SITE ORIENTATION

Tiksi Airport was established in the 1950s as a staging base for strategic long-range bombers. In 2012, Tiksi airport was suddenly closed to all aircraft except for helicopters from 01 October until 31 December with no public explanation. In 2014, the Russian Ministry of Defense announced that a restoration of the airport would be completed the following year to support the populations of eight new villages to be built in the region. Satellite imagery of the airport shows that no significant improvements were made to the airport during that period; the only notable change is the construction of a large building sometime between 2016-2020 which is visible upon comparison of Figures 76 and 77.

According to a press release from the Russian Federal State Enterprise in August 2016, Tiksi's runway had been deemed suitable to receive large aircraft due to the extension of usable runway from 1,800 meters to 2,220 meters. Despite this claim, satellite imagery shows no improvements to the runway surface until 2021. These recent repairs are located on the south end of the runway and would indeed lengthen the useable runway upon completion, albeit five years after the Russian government claimed the site suitable for large aircraft such as Tu-154s and Boeing-737s.

Figure 80:
Tiksi south taxiway erosion
Google Earth 07/16/2005

Figure 81:
Tiksi south taxiway erosion
Google Earth 09/02/2016

B. Indicators of Damage

Indicators of damage to infrastructure at Tiksi caused by thawing permafrost are evident on the runway surface, adjacent taxiways, and in areas that were likely excavated for construction purposes. Historical satellite imagery of the areas of the runway most recently under repair reveals visual indicators of damage in those same areas in years prior. Despite the low image quality, dark/ wet spots suggest damaged slabs that are lower than the surrounding slabs or low points on individual slabs. These damaged areas match up with the sections of runway that began to receive repairs in 2021.

Figure 78:
Dark spot indicators
Google Earth 07/27/2016

In addition to the above indicators, which are visible from 2016 until repairs began in 2021, imagery from September 2022 shows similar indicators across much of the airfield. These wet spots suggest that some slabs sit lower than others and require replacement to ensure that the runway is usable for fixed-wing aircraft.

At Tiksi, erosion is evident underneath portions of the taxiway. Indicators of surface failure on the south taxiway at Tiksi were apparent in 2005 as water near the raised embankment of the airfield began to erode the foundation and subsurface of concrete slabs.

By 2016, the taxiway erosion appears to have worsened, with no evidence of an attempt to repair it.

The taxiway remained in a state of disrepair until June 2021, when the surface slabs above this area were removed. As of September 2022, the surface had yet to be replaced; the construction effort appears to be focused on improvements to drainage and the embankment prior to slab replacement.

Many buildings within the footprint of Tiksi Airport have fallen into disrepair, possibly due to permafrost freezing and thawing beneath their foundations at a more severe rate. It is also possible that the deterioration of buildings is a result of abandonment and general neglect combined with the severe weather of the region. Buildings directly west of the terminal area at Tiksi have deteriorated significantly since 2005; note that permafrost signatures in the form of standing water and ice wedges are more apparent in 2020 as compared to 2005. Figures 82 and 83 provide a comparison of thermokarst feature development over this time period.

West of Tiksi's airfield, a delivery pipeline running from a now abandoned port to fuel storage tanks near the town of Tiksi completely collapsed sometime between 2006 and 2020. Imagery analysis is unable to conclude whether this damage is deliberate, the result of a severe weather event, thawing permafrost, or some combination of multiple factors. The contrast between Figures 84 and 85 is evidence of the pipeline becoming unusable due to a seemingly rapid vent, whatever the cause may be.

Indicators of Repairs

In the most recent imagery available, significant repairs were underway as of September 2022. In some cases, indicators of damage are visible and obvious prior to repair. The erosion of the taxiways at Tiksi is one such example and appears to have become significant enough to require repairs in 2022 to allow access to the full length of the runway.

Visible indicators of damage to the airfield surface itself are more difficult to ascertain beyond the previously highlighted low spot indicators, but the areas of major slab replacement on the runway are located near the TDZ. These sections under repair cover the same areas mentioned above where indicators of damage were previously present.

Repair Capabilities

Figure 82:
Tiksi support buildings
Google Earth 07/16/2005

Figure 84:
Tiksi pipeline west of the airfield
Google Earth 07/16/2005

Figure 86:
Tiksi taxiway repairs
Copyright MAXAR 09/25/2022

Figure 87:
Tiksi runway southern approach repairs
Copyright MAXAR 09/25/2022

Repair Capabilities

Concrete slabs are stored on the west side of the airfield as well as near Tiksi Sea Port. The slab reserve near the port does not appear to have been utilized for current repairs; some stacks of slabs appear to be sinking into rising surface water which has significantly increased since 2005. Figures 88 and 89 are another example of thermokarst indicators resultant from and proximate to human disturbance of the ground.

Slabs for the most recent repairs are first visible on-site in the summer of 2020, with repairs beginning one year later. The most recent available imagery, from September 2022, shows that the runway repairs still needed to be completed at that time. Figures 90 and 91 illustrate a portion of the pre-construction process that occurs onsite.

Indicators of Permafrost

Visual indicators of the presence of and potential threat from permafrost can be seen at Tiksi Airport and in the surrounding area. Significant ice wedge ground coverage, the emergence of more standing water in the summer months, and thermokarst ponds near the airfield and support facilities all pose a threat to the integrity of artificial surfaces and structures. Figures 92 and 93 provide just a few examples of the many permafrost indicators present at Tiksi.

Indicators of increasingly severe thawing of permafrost are apparent to the west of Tiksi Airport, where a thermokarst pond has increased in size since 2005, and a section of an unimproved service road appears to have been abandoned in favor of a diagonal off-road bypass. A comparison of Figures 94 and 95 illustrates how rapidly thermokarst indicators can emerge.

Figure 88:
Tiksi sea port slab storage
Google Earth 07/16/2005

Figure 90:
Tiksi airfield slab reserves
Google Earth 06/19/2020

Figure 92:
Ice wedges south of the runway
Google Earth 06/01/2021

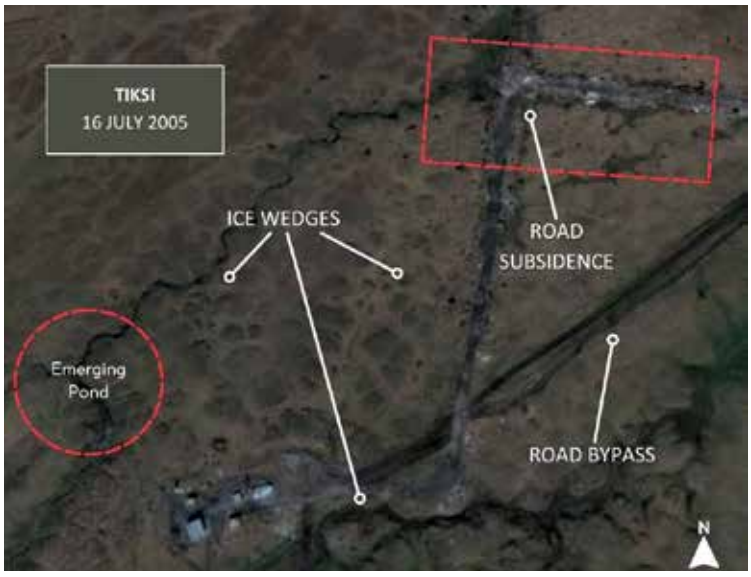
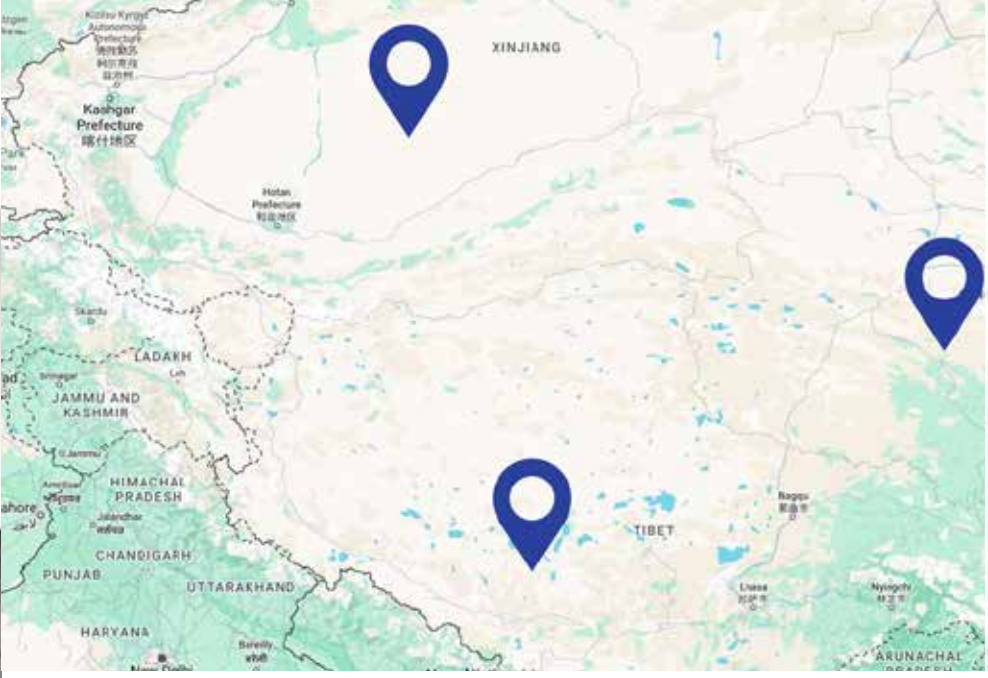


Figure 94:
Ice wedges and emerging thermokarst pond
Google Earth 07/16/2005

China's High-Altitude Heliports: Examining PLA Helicopter Force Changes

In partnership with Johns Hopkins University and written by Matt Humphrys

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil



OVERVIEW

Since 2017, the PLA has aggressively expanded its heliport network along the Sino-Indian border. The PLA's expansion is curious considering that many of its newest heliports are located at extreme elevations that may degrade its current vertical lift capability.

Findings suggest that this expansion may be an overzealous force projection mechanism underpinned by a slow-developing domestic rotorcraft capability. Furthermore, this expansion may also be the manifestation of the PLA's modernization efforts both technologically and doctrinally.

ACTIVITY

This GEOINT analysis uses imagery and GIS to assess the PLA's helicopter force changes in relation to its high-altitude heliport expansion along the Sino-Indian border.

INTRODUCTION

The Sino-Indian border dispute has a contentious and militant history spanning more than sixty years. Multiple conflicts, often deadly, have pockmarked areas along the border, further entrenching each country's position and diminishing any perceived chance at resolution. Two recent conflicts in 2017 and 2020 likely drove the PLA to invest heavily in military infrastructure in the region – particularly aviation infrastructure.1 The sheer number of new or upgraded airports/heliports near the Sino-Indian border is astounding. Between 2017 and 2021 the PLA broke ground on fifteen new airports/heliports along the Indian border with another twenty-two upgraded in Tibet and Xinjiang. While the PLA's airport expansion seems appropriately tailored to its fixed-wing capabilities, its heliport expansion is more puzzling. Tibet and Xinjiang host some of the highest elevations in the world that are coupled with mountainous terrain and harsh environmental conditions. This combination makes helicopter flight exceptionally difficult. If PLA rotorcraft can operate near the border without operational degradation, this will be a testament to its growing vertical lift capability. If the PLA cannot effectively operate in the region, its heliport expansion is likely wasting resources. This geospatial intelligence assessment examines Chinese high-altitude heliports near the Sino-Indian border to evaluate the PLA's vertical lift capability in the region and how the PLA might leverage these facilities in the future.

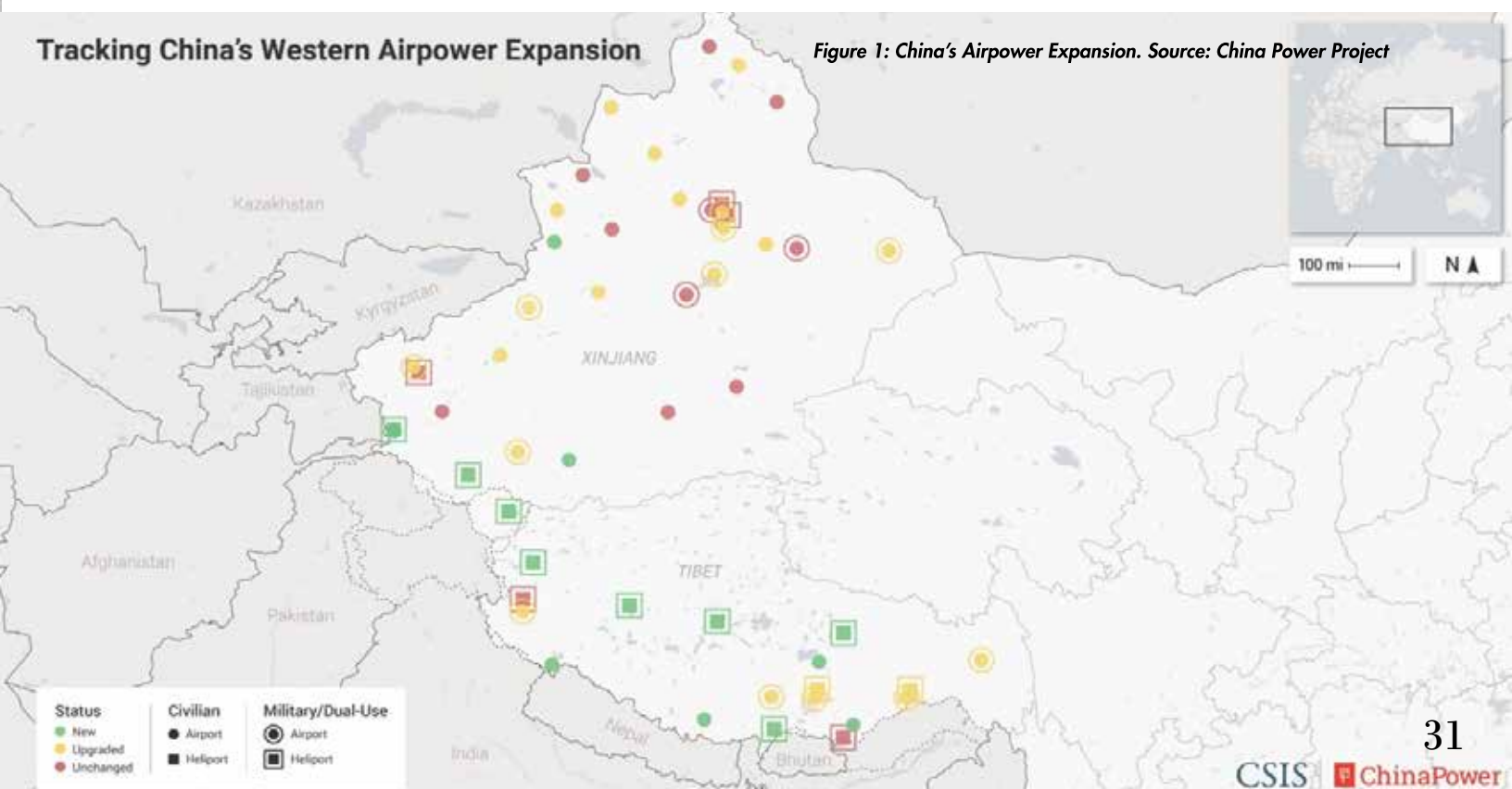


Figure 1: China's Airpower Expansion. Source: China Power Project

Key Judgements

- The PLA high-altitude heliports probably serve as tactical logistics hubs as evidence by their placement in an interconnected network of valleys.
- High-altitude heliport construction is probably behind schedule.
- The PLA will may leverage heliports as a dual-use Unmanned Aircraft Systems (UAS) infrastructure.
- The PLA will probably continue to rely on Russian helicopters to fill capability gaps.

Key Assumptions

- (Primary) Little evidence suggests that PLA helicopters are currently suited for sustained high-altitude combat flight operations; however, helicopter performance is also difficult to determine without authoritative performance data. As such, it is assumed that PLA helicopters are probably not capable of full-spectrum operations in high-altitude environments – especially along portions of the Sino-Indian border.
- For the purposes of this assessment, "high-altitude" is defined as an elevation at or above 14,500 feet mean sea level (MSL). While the elevation figure is arbitrary, it does represent a benchmark at which military rotorcraft operations become exceedingly difficult.
- For the purposes of this assessment, "full-spectrum helicopter operations" is defined as the ability to perform all missions intended by the PLA. The inability to perform "full-spectrum helicopter operations" may be the complete lack of a certain capability (i.e. attack aircraft cannot fly in the region) or a degradation of a capability (i.e. an aircraft can only transport two soldiers instead of eight).

Analytical Gaps and Limitations

- This assessment does not evaluate the current or proposed PLA order of battle. While examining the order of battle likely holds additional insights, this is beyond the scope of this assessment.
- This assessment only evaluates helicopter activity at heliports. It does not evaluate airports, including those with helicopter infrastructure. As of June 2023, no Chinese airports were located above 14,500 feet MSL.
- Reporting from Chinese sources is likely state-affiliated or portrays state-sanctioned information. As such, the validity of Chinese information may be inaccurate and often overstated.

Figure 2: Disputed Sino-Indian Border and Territory. Source: Reuters via the Voice of America News

FRAMING THE DISCUSSION

After Mao Zedong's establishment of the People's Republic of China (PRC) in 1949, China rejected previously agreed-upon borders with neighboring countries including India. This rejection caused a militant border dispute between India and China that remains tense to this day. Figure 1 shows the disputed border and territories. The disputed portions of the border, known as the Line of Actual Control (LAC), is one of the primary factors contributing to ongoing regional disputes.

Two border clashes in 2017 and 2020 appear to have catalyzed the PLA's infrastructure expansion in the region. Both the Doklam conflict (2017) and the Ladakh conflict (2020) turned deadly, prompting outrage from both countries and military buildup. Prior to 2017, the PLA operated only five heliports along the border. The current heliport expansion grows that number to thirteen. According to the CSIS China Power Project, most new heliports and/or heliport upgrades started construction in approximately 2020.

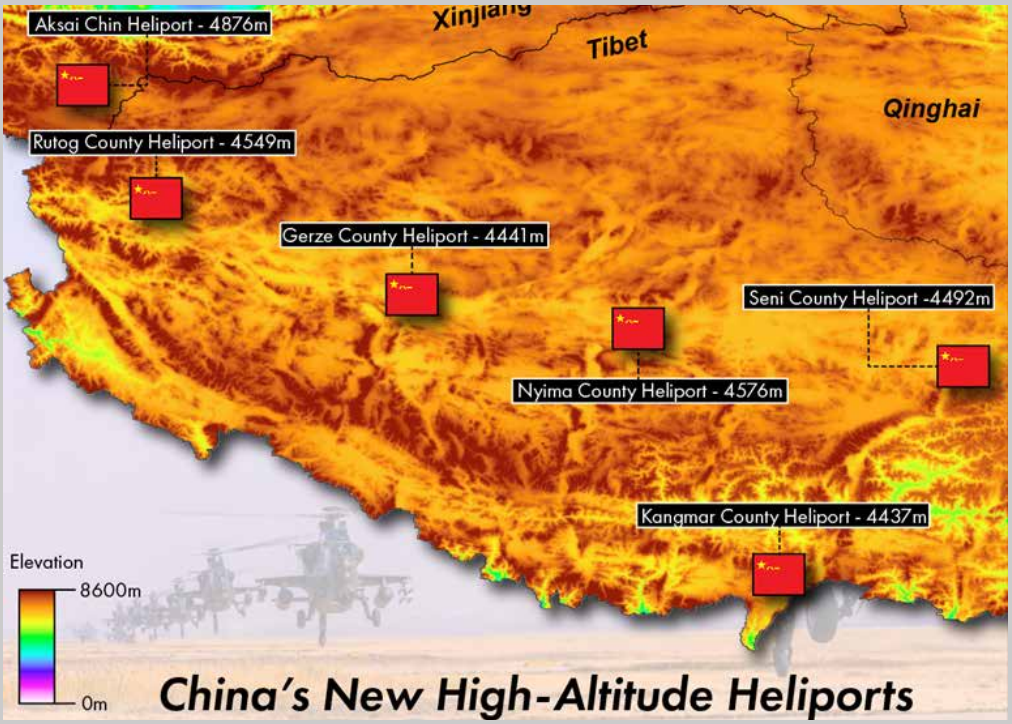


Figure 4: China's New High-Altitude Heliports above 14,500 feet (4,420 meters) MSL. *Source: Original Work, Author. Data: China Power and ArcGIS Online*

Six of the eight new heliports within the area of interest are located at or above 14,500 feet MSL. Figure 4 shows the regional dispersion of these six heliports.

The PLA's helicopter fleet comprises utility, heavy lift, and attack platforms. Over the last decade, the PLA increased the quantity and type of its helicopter inventory. Historically, the PLA relied on foreign-built platforms such as the Russian Mi-17. However, in recent years the PLA has made a concerted effort to increase its force with domestic solutions. Figure 5 shows the PLA's helicopter inventory breakdown from 2011 to 2021.

Four PLA helicopters stand out as possible candidates for high-altitude operations across China's western border: the Mi-17, Z-8, Z-10, and Z-20 (Figures 6-9). These aircraft operate in the region and likely have the capability to do so with some degree of effectiveness. Furthermore, multiple Chinese media outlets such as Central China Television have touted that these four airframes are ready for high-altitude operations.

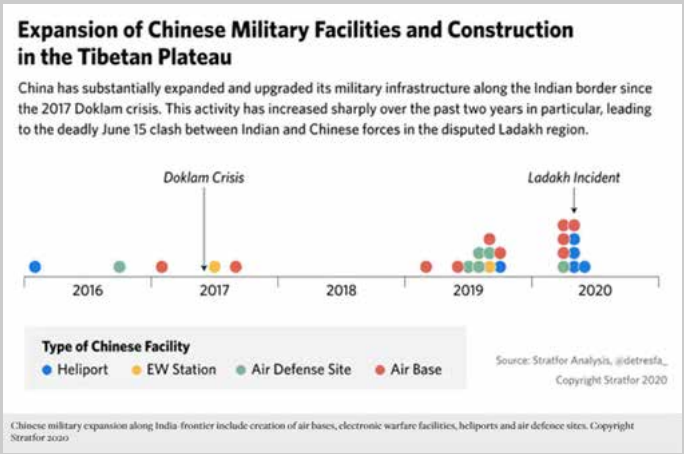


Figure 3: PLA Infrastructure Expansion Related to Border.
Source: Stratfor and @detresfa_ via the Central Tibetan Administration

Helicopter	2011	2012	2020	2021
Attack/Recon				
2-10	10	16	150	150
2-19	0	0	120	120
Z-9	126	226	234	234
Lift				
Heavy: Z-8	7	17	105	111
Medium: Mi-17	200	200	278	278
Medium: Z-20	0	0	12+	24+

Figure 5: PLA Helicopter Force 2011-2021
Source: Tom Fox (U.S. Naval War College - China Maritime Studies Institute)

Figure 6: PLA Mi-17. Source: Mu Yun via www.airliners.net

The heliport expansion is also being conducted against the backdrop of military modernization. In 2013, China's Central Military Commission (CMC) began a series of military reforms to modernize capabilities, organizational structure, and doctrine. Some examples of this modernization include the establishment of theater commands, the Joint Logistic Supply Force (JLSF), and the integration of novel technologies such as autonomous and unmanned systems (Figures 10-12). Considering the long-term and strategic nature of the CMC's modernization efforts, it is possible that the PLA's heliports are designed and implemented to account for changes in doctrine and technology. The potential gaps in operational helicopter capability may be opportunities for the PLA to flaunt its perceived advancements.

Figure 10: PLA Theater Commands *Source: Stratfor*

Name	Status	Region	Elevation (m)	Latitude	Longitude
Aksai Chin Heliport	New	Xinjiang/Tibet	4876	35.24623	79.54323
Nyima County Heliport	New	Tibet	4576	31.78837	87.30002
Rutog County Heliport	New	Tibet	4549	33.6544	80.44809
Seni County Heliport	New	Tibet	4492	31.41498	91.98397
Gerze County Heliport	New	Tibet	4441	32.29913	84.02879
Kangmar County Heliport	New	Tibet	4437	28.28458	89.40484
Cuona Heliport	Unchanged	Tibet	4366	28.00598	91.9643
Ngari Heliport	Unchanged	Tibet	4290	32.49611	80.07167
Xaidulla Heliport	New	Xinjiang	3673	36.34545	78.03122
Lhasa Heliport	Upgraded	Tibet	3630	29.58923	91.0185
Tashkorgan Heliport	New	Xinjiang	3150	37.72496	75.2566
Nyingchi Heliport	Upgraded	Tibet	2957	29.56119	94.47012
Golmud Heliport	New	Qinghai	2857	36.38641	94.79804
Shule Heliport	Unchanged	Xinjiang	1253	39.39954	76.19433
Zhangpu Heliport	New	Fujian	32	24.04492	117.84815
Heliports in red are designated as "high altitude"					

Table 1: Imagery Target Deck
Source: Original Work, Author. Data: China Power Project

ANALYTIC METHODOLOGY

Fifteen heliports were designated for satellite imagery analysis (Table 1). Six primary targets (heliports at or above 14,500 feet MSL (4,420 meters) and nine secondary targets (other heliports) were selected. The secondary targets offered key insights for comparative analysis. Fourteen of the heliports are in western China. One recently constructed heliport, located in southeastern China, was included for additional comparative analysis. A geographic information system (GIS) was used to assess two factors: regional elevation and heliport placement. Analysis of the proximate elevation was conducted to ascertain what elevations PLA rotorcraft are expected to operate at. The heliport placement analysis was designed to determine any key terrain, unique geography, or other relevant factors about the heliports' placement that might give insight into the PLA's intentions.

KEY JUDGEMENTS

The PLA High-Altitude Heliports Probably Serve as Tactical Logistics Hubs as Evidenced by their Placement in an Interconnected Network of Valleys

All high-altitude heliports are located at intersections of valley systems that connect the heliports to one another and to the western border. The valley system likely provides three advantages necessary for operations. First, the valley system takes advantage of lower elevations which helps preserve already limited helicopter performance. Second, the valley system probably provides a safer and more predictable route structure during poor weather navigation. Janes indicates that PLA helicopters may be equipped with terrain-following radar. This may be the primary means of navigation in the absence of reliable instrument navigation infrastructure. Third, the valley system may provide protection from enemy weapon systems that may seek to detect, track, or destroy PLA aircraft. In a region where the transportation infrastructure is dominated by roads of varying conditions, the heliports may provide the PLA with a much more timely and tactical logistics solution.

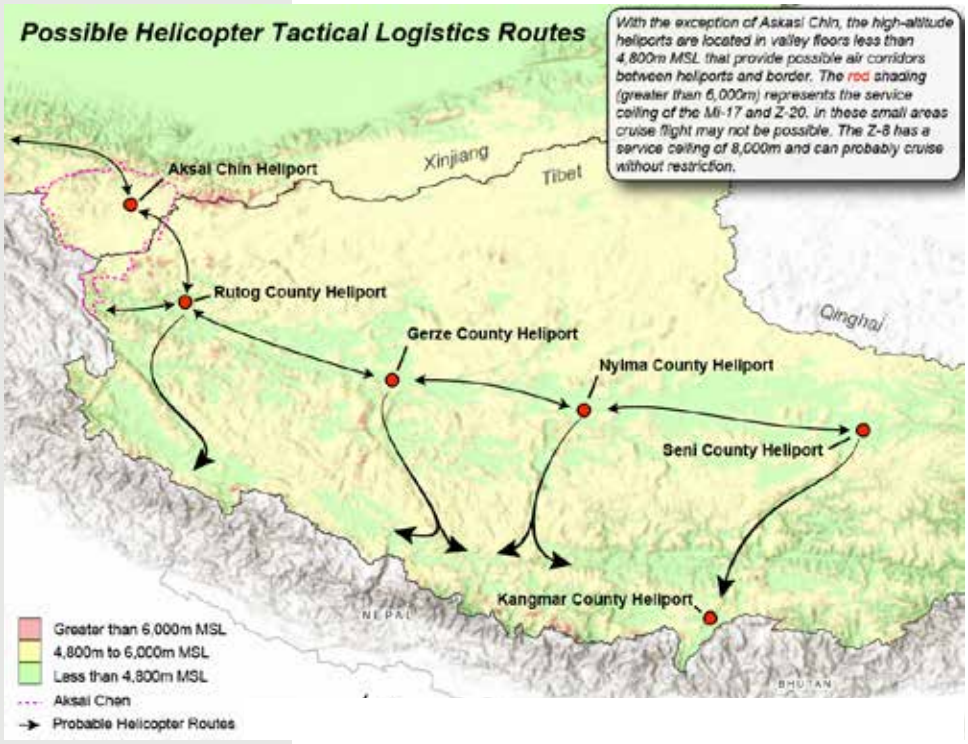


Figure 13: Source: Original Work, Author. Data: China Power and ArcGIS Online

High-altitude Heliport Construction is Probably Behind Schedule

Imagery analysis suggests that heliports constructed at lower altitudes took approximately 18 to 24 months to complete. Conversely, despite start dates in approximately 2020, all heliports above 14,500 feet MSL remain under construction. Figures 14-19 contain imagery depicting signs of this construction. Some signs of construction are more blatant than others. For example, some heliports still lack a runway (Figures 18 and 19) and/or show incomplete hangars (Figures 16,18, and 19). Other indications are more nuanced such as the presence of airfield lighting trenches (Figure 14 and 17). Many operational airfields and heliports contain what are probably munitions bunkers (Figure 15). This may serve as another progress marker for those new heliports lacking this feature (Figure 14). Considering the challenging logistics needed to construct heliports at high-altitude, it is probable that the delays are logistics-related.

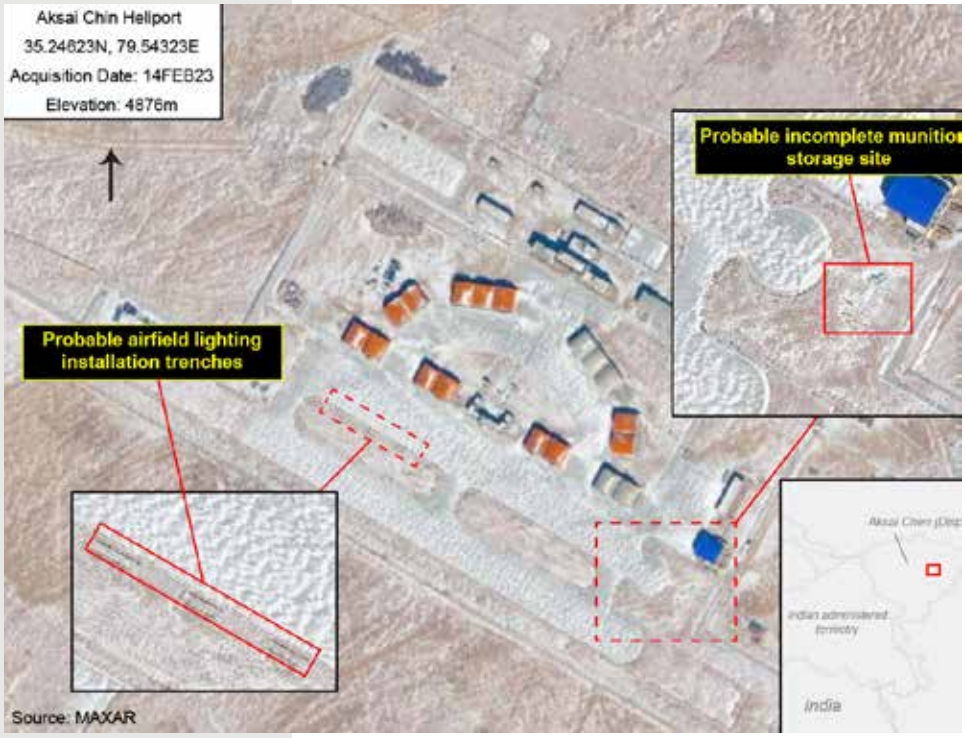


Figure 14: Aksai Chin Heliport

The PLA May Leverage Heliports as a Dual-use UAS Infrastructure

Imagery and open-source reporting revealed that UAS likely operate from heliports across China. In 2021, The Drive first reported the presence of UAS at the Lhasa heliport in Tibet (Figure 21). Imagery analysis also revealed the presence of UAS at the newly constructed heliport in Fujian (Figure 22). While not located in China's Western Theater, it is one example of a newly constructed heliport with this type of activity. No UAS were detected in the satellite imagery review of the remaining thirteen heliports; however, fixed wing aircraft were observed on helicopter bases in China – further supporting a precedent for dual-use fixed wing activity at heliports (Figure 23).

Figure 21: UAS located at the Lhasa Heliport: Source: The Drive

The presence of turning circles on newer heliports may be a feature designed for fixed wing aircraft, particularly UAS, on short runways. A turning circle on the runway likely has little utility for helicopters; however, this feature would allow a fixed wing platform to maximize the entire length of the runway for takeoff and landing - a critical requirement at high altitude. The turning circles do give the appearance of a possible helicopter landing point: the circles are not marked as a helipad and lack designated lighting that marks the area as a landing point. Figure 24 shows an example of the turning circle at Goldmud. The square helipad is marked with the traditional "H" and has designated lighting that marks the helipad boundaries, but Golmud's turning circle is not marked as a helipad and lacks lighting along its circumference.

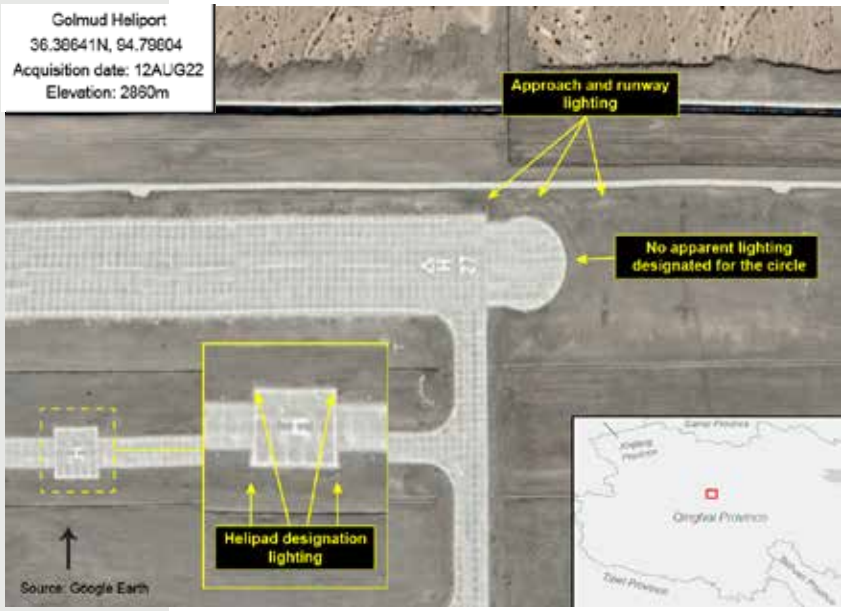


Figure 24: Golmud Heliport turning circle and lighting configuration

The average length of the high-altitude heliport runways is approximately 600 meters. At high altitude, this length may be insufficient for many fixed wing UAS in the PLA's inventory; however, it may be ideally suited for short takeoff and landing (STOL) UAS. Various Chinese media outlets, including the Global Times, purports that the PLA and JLSF are evaluating a variety of STOL UAS designed for cargo and can operate from short runways and in the high-altitude environment of western China. One example is the AT200 (Figure 25), a modified version of Pacific Aerospace's (NZL) P750XTOL (Figure 26). This aircraft is able to operate to and from runways measuring less than 200 meters. Considering the resource-hungry nature of helicopter operations and high-altitude logistics, STOL cargo aircraft may be ideally suited for expeditiously resupplying these strategic nodes or the elements the helicopter force supports.

Figure 25: Chinese AT200 STOL UAS. Source: Xinhua News Agency

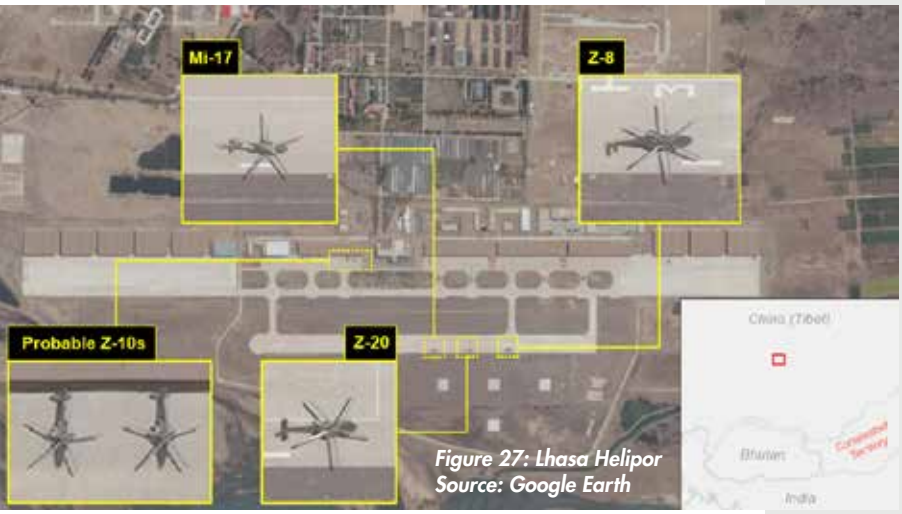


Figure 27: Lhasa Helipor
Source: Google Earth

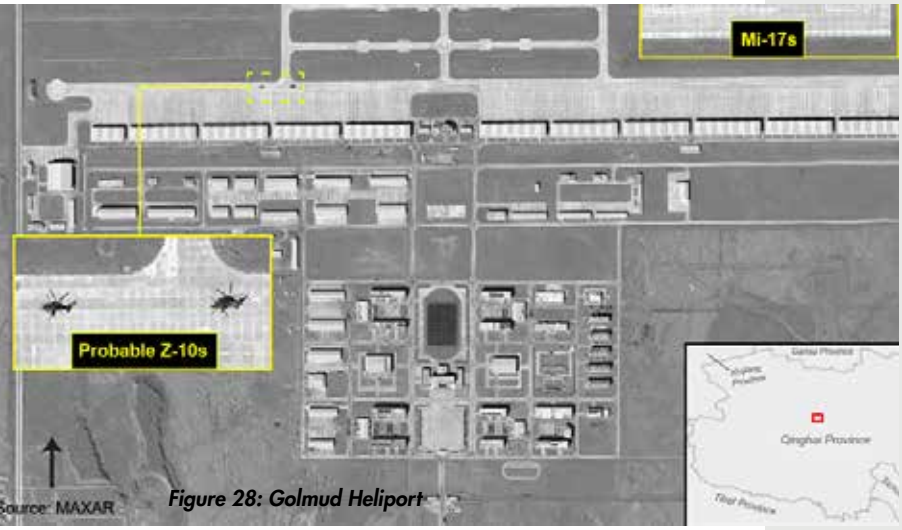


Figure 28: Golmud Heliport

Figure 29: Mi-17s with and without weapons pylons at the Shule Heliport. Imagery
Source: MAXAR, (left) www.china.org.cn, (right) www.airliners.net

The PLA Will Probably Continue to Rely on Russian Helicopters to Fill Capability Gaps

A comparative analysis of operational heliports in the region revealed an overwhelming presence of Mi-17s. While Chinese Central Television suggests that other airframes have been operating in the WTC, imagery collection over the past two years almost exclusively shows Mi-17s at heliports.The only exceptions were the Lhasa and Golmud bases – the two largest heliports in Tibet and Qinghai respectively and located at much lower altitude. At both heliports, the Mi-17, Z-8, Z-10 (probable), and Z-20 were identified (Figure 27 and 28).

The Mi-17 outnumbers the Z-8 at approximately 2:1 and the Z-20 more than 20:1. It is possible that the large presence of Mi-17s in the region says more about airframe availability than capability. As operations continue and more heliports are operationalized, it will be important to monitor whether Z-8, Z-10, and Z-20 activity expands. Regardless, the PLA's reliance on the Mi-17 remains.

Furthermore, in 2020 The Drive reported that the PLA may be investing in newer versions of the Mi-17 that likely provide better high-altitude performance.If the PLA is investing in new Mi-17 helicopters for performance, this is further evidence that the PLA's domestic solutions are not yet comparable to Mi-17 and/or the domestic production rate is lagging.

Satellite imagery analysis also revealed Mi-17s configured with probable weapons pylons. If this configuration continues to be observed in place of dedicated attack aircraft, it could indicate that the Russian platform is more capable at high altitudes than its domestic attack solution. Figure 29 shows
the satellite imagery of an Mi-17 with and without the weapons pylons (top). Examples of what the configuration probably looks like is shown below each satellite image.

Lastly, Reuters indicates the Chinese and Russians are collaborating on the AC332 AHL, a joint-heavy lift helicopter destined for the Western Theater. The AC332 AHL is predicted to be the PLA's highest performing heavy lift helicopter. The helicopter will be designed to carry 600kg loads at 4500 meters.Model rendering resembles an enhanced Z-8 or a loose attempt at mimicking the United State's CH-53's heavy lift design. The AC332 AHL collaboration agreement between China and Russia was signed in 2016 and still appears to be in the design phase. If the AC332 provides a capable and affordable heavy-lift solution, it could be a viable high-altitude platform that exceeds the capability of its current force.

SO WHAT?

The PLA's use of its high-altitude heliport network as force projection mechanism is probably over-zealous

The apparent and significant delays in high-altitude heliport construction is one probable indication of the challenges related to high altitude. Furthermore, the lack of operational sites leaves the larger force still untested. When combined with the PLA's historically sparce presence in the region, the force projection it aims to display may be established on a rocky foundation.

The PLA's domestic rotorcraft program is probably not mature enough to handle large-scale operations at high altitude

The PLA, whether by intent or fortuity, appears continuously reliant on Russian aircraft. The sheer number of Mi-17s in the PLA's inventory (particularly along the Sino-Indian border), continued investment in new Mi-17 airframes, and evidence of future Sino-Russian collaborative rotorcraft programs give substance to this assertion. The PLA, at least in public forums, have immense pride in their ability to provide a domestic rotorcraft capability; however, little evidence suggests that this capability is prepared for the challenges of sustained full-spectrum and large-scale operations at high altitude at this time.

Figure 30: AC332 AHL concept model
Source: Public Defense Channel (YouTube)

The PLA's high-altitude heliport network is probably a manifestation, both technologically and doctrinally, of its military modernization efforts

As the CMC continues its modernization efforts, it is possible that the heliport network is designed to facilitate tactical, operational, and/or strategic goals that are in alignment with its new doctrinal tenets. If true, the PLA's vertical lift capability may fulfill different objectives at high altitude (i.e. strategic logistics) compared to legacy capabilities at lower altitude (i.e. air assault). This notion is further reinforced by evidence of the PLA integrating novel technologies such as unmanned aircraft into its fold. Whether these technologies are integrated as a part of modernization efforts, filling capabilities gaps, or both, the developing heliport network may be an example of its modernization methodology at work.

WHY CHINA'S HIGH-ALTITUDE HELIPORTS ARE AMBITIOUS

Given the sustained tension between India and China, the PLA's desire for an expanded helicopter infrastructure is not surprising. This desire is probably reinforced by a historically lackluster disaster response capability in the region. Previously, vast expanses of Tibet and Xinjiang were void of a helicopter capability that will now be more readily filled. If executed well, the improved network could provide a quicker military response to conflicts or disasters and improve military logistics along the border.

The predominant factor that likely complicates this project and future regional sustainment is the extreme altitude itself. War on the Rocks suggests that the Sino-Indian border altitudes are extreme enough to cause acclimation issues, degrade logistical capabilities (i.e. poor diesel engine performance), and alter combat norms (i.e. ballistics) that may negatively impact fundamental soldiering. When combined with regional environmental considerations such as extreme temperatures and mountainous terrain, the matter is complicated further.

Helicopters are also not immune from these challenges and are uniquely vulnerable to the negative effects of high altitude. Simply stated, the higher in altitude a helicopter operates the less capable its rotor blades are producing lift and the less power its engines can generate. The helicopter is also prized for its ability to hover. It is the helicopter's ability to hover that provides much of its military advantage. Hoisting operations, equipment sling loads, and troop fast rope insertions are three examples of helicopter capability predicated on its ability to hover. Hovering flight, specifically high hovering flight, is extremely power intensive. As such, it is one of the first capabilities lost at high altitude, or requires drastic modifications to helicopter loading (less fuel, armament, and/or cargo) to maintain. Lastly, high altitude negatively impacts a helicopter's ability to dynamically maneuver. Maneuverability is of marginal importance during peace-time operations but is critical during combat.

The summation of these factors presents a formidable challenge for the PLA. First, the PLA will likely grapple with the logistical challenge of heliport construction and sustainment at extreme elevations. Second, the PLA will almost certainly experience a degradation in helicopter performance, though to what extent is unknown. Both of these considerations stand to negatively impact China's combat effectiveness in the region without deliberate mitigation strategies.

Contributor Note

The author is an active duty H60 instructor pilot with over fourteen years of service between the United States Army and the United States Coast Guard. The report is a product of the author's student role but draws upon aggregate past experience and does not represent an official position of past employers.

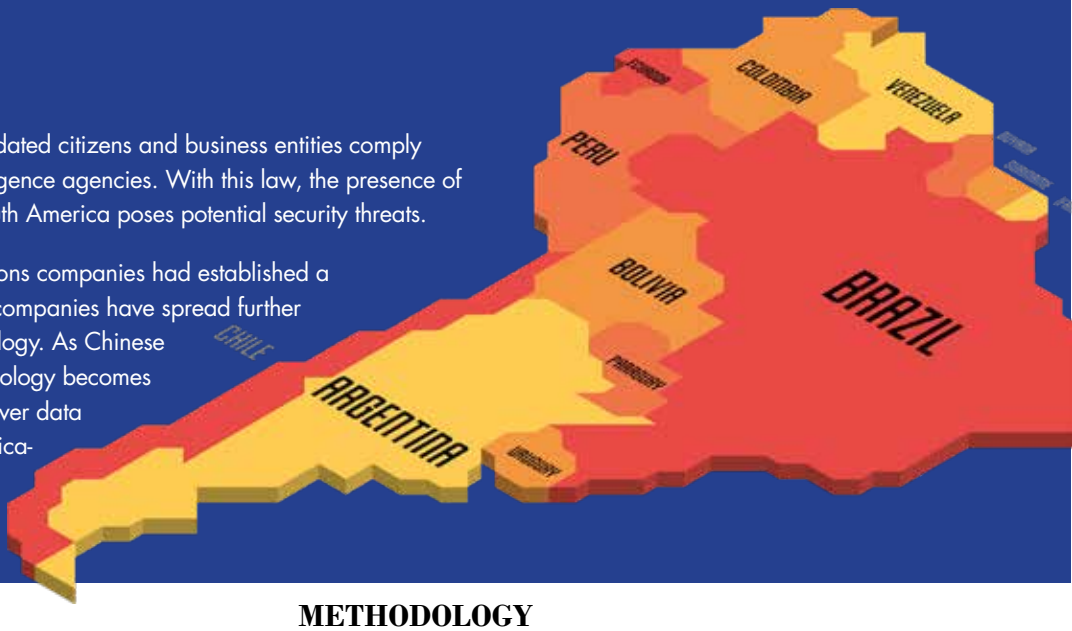
China's Growing 5G Presence in South America Poses Potential Security Threats to the Region

In partnership with The Global Disinformation Lab at The University of Texas at Austin and written by Kim Nguyen and Varij Shah

OVERVIEW

In 2017, a Chinese national security law mandated citizens and business entities comply with requests for information by Chinese intelligence agencies. With this law, the presence of Chinese telecommunications companies in South America poses potential security threats.

As of 2022, multiple Chinese telecommunications companies had established a presence in South America. Since then, these companies have spread further throughout the region, proliferating 5G technology. As Chinese prominence in the region grows and 5G technology becomes more integrated into people's lives, concerns over data autonomy, corporate espionage, and communications grid vulnerabilities will become more central in the debate over how 5G development should progress.



ACTIVITY

A recent Chinese national security law presents potential security implications for the expanding presence of Chinese telecommunications companies in South American 5G networks, specifically Brazil, Argentina, and Venezuela. The geolocated data throughout this study documenting China's telecommunications presence in South America helps one understand and manage risk.

5G cellular networks represent a major leap forward in telecommunications technology, offering increased internet connection speed and facilitating the implementation of new technologies, including autonomous vehicles, augmented reality, and the Internet of Things. However, as 5G technologies become more widespread and deeply integrated–personal, corporate, and governmental information becomes more accessible and susceptible to hacking or cyberattacks. Moreover, a deeply interconnected 5G system may prove difficult to isolate and fully protect. As such, the realm of telecommunications provides a new avenue through which countries can gather intelligence and grow their global influence. Given the structure of its national security laws, China has the potential to take advantage of this new opportunity.

METHODOLOGY

This study utilizes open reporting and commercial satellite imagery to examine the extent and potential impacts of Chinese telecommunications expansion and 5G infrastructure deployments in South America using Brazil, Argentina, and Venezuela as the cross-section samples. Geospatial analysis is supplemented with an extensive review of press, corporate, and government documentation. Initial data on the presence of Chinese telecommunications companies in the region as of mid-2022 was provided by researchers at James Madison University and is accessible at this ArcGIS Dashboard, pictured in Figure 1. At the end of this article, we provide a downloadable Excel sheet of this data and KML and Shapefiles displaying those locations which are mappable at a high level of precision.

Recognizing 5G infrastructure in satellite imagery is difficult since cell towers leave a small aerial footprint and 5G infrastructure is often nearly identical, if not fully identical, to 4G infrastructure. 5G infrastructure consists of small-cell and macrocell base stations, which are essential for providing high-quality service to urban and rural areas, respectively. These physical pieces of infrastructure form a 5G network. However, not all 5G infrastructure is dedicated to 5G alone; it is frequently an extension of existing 4G infrastructure with hardware and/or software augmentations. This situation, where 5G service depends on a 4G core of infrastructure, is known as Non-Standalone Architecture and complicates the ability to visually differentiate between 4G and 5G infrastructure.

Figure 1: ArcGIS Dashboard of Chinese Telecommunication Companies in Argentina, Brazil, and Venezuela as of 2022.
Courtesy of researchers at James Madison University. 36 points of presence in total

CHINESE NATIONAL SECURITY LAW

The Chinese government's relationship with domestically-owned telecommunications companies makes their global expansion a unique security threat. China's 2017 national security law mandates that domestic entities cooperate with the government when requested.

- Article 7 states: "Any organization or citizen shall support, assist and cooperate with the state intelligence work in accordance with the law, and keep the secrets of the national intelligence work known to the public. The State protects individuals and organizations that support, assist and cooperate with national intelligence work."
  - o Simply, this article casts the broad brush that national security cooperation is everyone's business as a citizen of China.
- Article 10 states: "The state intelligence work agencies shall use the necessary methods, means and channels to carry out intelligence work at home and abroad according to their work needs.
  - o Simply, this article can compel Chinese overseas businesses to hand over data for broad national security purposes.
- Article 11 states: "The state intelligence work institutions shall collect and handle the acts or acts of foreign institutions, organizations and individuals that are implemented or instructed or funded by others, or colluded by domestic and foreign institutions, organizations and individuals to endanger the national security and interests of the People's Republic of China. Relevant information provides information or reference for preventing, stopping and punishing the above actions."
  - o Simply, this article allows Chinese intelligence agencies to process information on foreign actors that they deem to be jeopardizing national security interests.
- Article 14 states: "The state intelligence work organization shall carry out intelligence work according to law, and may require relevant organs, organizations and citizens to provide necessary support, assistance and cooperation."
  - o Simply, this article empowers intelligence agencies to compel civilians to collaborate with them.

The 2017 Chinese National Security Law outlined above requires those under Chinese jurisdiction to renounce all information that may be relevant to national security. In essence, Chinese intelligence agencies are empowered to compel Chinese individuals and companies to assist them in collecting intelligence on other countries. This ability to requisition company data is uniquely useful when applied to telecommunications companies that operate abroad, since telecom companies process huge amounts of information, some of which is inevitably sensitive. Any company or individual data that is held on a device linked to a Chinese telecommunications company could potentially be exploited for Chinese intelligence interests. This leaves 5G users in regions with Chinese 5G networks vulnerable to Chinese cyber threats and intelligence collection.

U.S. CONCERNS

Concerned about the implications of the 2017 Chinese National Security Law, in the Fall of 2021 the United States officially banned Huawei, ZTE, and some other Chinese telecommunications companies from receiving new equipment licenses from American regulators. US concerns can serve as a useful risk framework for other regions such as South America.

CHINESE TELECOMMUNICATIONS IN SOUTH AMERICA

Globally, Chinese companies are leading the charge in developing and implementing 5G technology. This market dominance is in part due to the direct support that Chinese domestic telecommunications companies have been receiving from the government since 1996. For example, Huawei, the world's largest telecom company, has become a major player in the race for 5G both within the Chinese domestic market and on the world stage. Huawei has received $75 billion in support from the Chinese government since its founding, helping it to support a research and development budget comparable to that of Amazon, Inc. Using this governmental support, Huawei and other Chinese companies have developed expertise in 5G technology. In addition to developing highly functional products, this financial backing has enabled Chinese corporations to sell their products at artificially low prices, sometimes even below the cost of production. As a result, countries around the world have courted the business of Chinese telecom companies for their low prices and advanced technology to include South American markets.

Since the rise of 5G technology, Chinese telecommunications companies like Huawei and ZTE have moved into South America to expand their market presence. As more Chinese companies penetrate the South American market and gain greater market share, they gain access to an increasing amount of user data. In Venezuela, Brazil, and Argentina, a number of Chinese telecommunications companies have established a presence in densely populated areas.

ZTE currently has five offices across the three countries, and Huawei has established nine offices in eight Latin American countries. A data center owned by China Unicom Global is pictured below in Figure 2 for context and characterization.

Figure 2: China Unicom Data Center in São Paulo, Brazil (Note the cooling units on the roof)

As of 2022, Huawei, ZTE, China Unicom, China Telecom, and China Mobile had established at least 36 facilities, including offices, data centers, and other points of presence across these three South American countries. The locations of these facilities are pictured here in Figure 3.

Figure 3: Locations of known Chinese telecom facilities in South America as of 2022.

VENEZUELA

In Venezuela, the increasingly autocratic Maduro government has embraced the internet as a weapon of social control, progressively monitoring and restricting access since 2018. ZTE and Huawei have established particularly close relationships with the Maduro administration. In a nominal effort to strengthen national security, the government paid ZTE $70 million to build a database that collected civilian information including medical records and voter history. During a May 2019 speech, Maduro announced that the 5G rollout in Venezuela would be spearheaded by Huawei, and also denounced U.S. restrictions against the company. Maduro remains in power and has continued to strengthen relations between Venezuela and Chinese telecommunications companies. In 2021, he welcomed further collaboration with ZTE on 5G development. Figure 4 below displays a sample of ZTE's corporate presence in the country.

Huawei has also been an integral part of Venezuela's telecommunications modernization projects from 2006 to 2019, bolstered by Chinese "oil for loan/goods" agreements. As a result, Huawei technologies are integrated across the Venezuelan telecommunications network. Movistar, a prominent Venezuelan cellular provider, leases its LTE capacity from Huawei, an arrangement that has been in place as early as 2014. (LTE stands for "long-term evolution" which is a standard for wireless broadband communication for mobile devices and data terminals). Reuters reported in 2018 that the widespread failure of Venezuela's CANTV – the country's state-run telephone and internet service provider – to reliably cover much of the country has also increased reliance on Huawei local internet uplinks in many suburban and rural areas. Huawei has also been involved in an ongoing partnership with CANTV to upgrade its aging telecommunications infrastructure by providing equipment since at least 2006.

Figure 4: ZTE Offices in Caracas, Venezuela. December 2022

Figure 5: China Unicom Data Center in São Paulo, Brazil.
Source: Google Earth November 2022

BRAZIL

Brazil has had a less consistent relationship with Chinese telecom companies due to former President Jair Bolsonaro's opposition to Huawei's involvement in the country. Nonetheless, the company's equipment is already used in most 3G and 4G networks provided by Brazilian telecommunication firms. Bolsonaro's denunciation occurred around the time when the U.S. government was urging other countries to ban Huawei from 5G network expansion due to surveillance concerns. Nonetheless, Brazilian efforts are underway to implement 5G technology across the country, thus becoming more economically intertwined with China. Reuters reports that Brazil's current President, Luiz Inácio Lula da Silva, is determined to build a relationship with China and Huawei to expand its 5G communications infrastructure. Already, the telecom giant controls 50% of the country's telecommunications equipment market, and has a factory employing 2,000 people in São Paulo, with another $800 million facility on its way. Huawei has trained 600 professionals on telecommunications installation techniques. These new jobs and facilities build on the existing 40% of 4G network components installed before the 5G transition. In a recent 5G frequency band auction, numerous companies that use Huawei components and partnerships extensively were awarded contracts to operate 5G networks in Brazil. To date, 5G networks have opened and expanded ahead of schedule across several major metropolitan areas, including Brasília, João Pessoa and São Paulo. To supply new 5G infrastructure and devices to the region, Huawei also opened a new "smart factory" in São Paulo in 2022.

Figure 6: Possible Cell Tower (Zoomed view).
Source: Google Earth November 2022

ZTE also has a strong presence in Brazil, which accounted for 9% of ZTE's overseas revenue in 2011. That same year, ZTE agreed to invest in a high-tech industrial park in Hortolandia, São Paulo. This industrial park was slated to include the company's first research and development facility in Latin America as well as a production plant, a training center, and a logistics center. The new facilities, estimated to cost $250 million, were expected to create 2,000 local jobs, though there is no recent textual or geospatial evidence confirming the implementation of this park. Despite the lack of evidence of the construction of this facility, ZTE has continued to expand its presence in Brazil through partnerships and technological development. ZTE has worked with various local manufacturers, including Vivo in 2016 and Qualcomm Technologies in 2019, to meet its infrastructure needs in Brazil. In 2023, Brazil's National Telecommunications Agency (Anatel) approved ZTE's new MC8020 5G modem for production in Brazil. The ZTE-Anatel partnership is ongoing.

China Unicom Global (CUG), a Chinese state-owned telecommunications operator, is also developing a large 5G presence in South America. CUG operates in Brazil under its subsidiary China Unicom (Brazil) Telecom Co., which was founded in 2016. Their partnership with privately owned American internet services company Equinix created the foundation for 5G service offerings to expand.

Since 2017, Equinix has constructed numerous data centers throughout Brazil, and CUG has begun utilizing them. These data centers, aimed at supporting 5G infrastructure, will bolster CUG's ability to promote internet connectivity. However, there are few mentions of demarcation points or other 5G infrastructure terms associated with China Unicom (Brazil) found in open reporting following the initial announcement in 2017. This lack of open reporting suggests that the construction of additional 5G infrastructure could still be in development or delayed.

Figures 5 and 6 display a possible cell tower and 5G point of presence for China Unicom in São Paulo, Brazil as contextual examples of infrastructure types. Although it could not be confirmed that the cell tower represents 5G infrastructure as opposed to 4G infrastructure, the potential security impacts posed by China's 2017 national security law would be present regardless of which technology the Chinese telecommunications company is implementing.

ARGENTINA

Huawei, ZTE, and other Chinese corporations have played a similarly prominent role in Argentina's telecommunications sector. The facilities of these two companies are pictured below in Figure 7. Huawei has been present in Argentina since 2001, cementing its role as a top telecommunications provider in the country. According to the Buenos Aires Times, Huawei has been in direct contact with the Argentine Foreign Ministry since 2020 to discuss its 5G implementation. Huawei employed 500 Argentines as of 2020 before 5G implementation began. Huawei leads Argentinian 5G implementation, building on existing 4G frequencies operated by Telecom Argentina. Telecom Argentina has implemented 20 5G sites using Huawei, Nokia, and Ericsson antennae across Argentina as of March 2022. In 2019, ZTE signed a $30 million contract with the Jujuy province to "provide cameras, monitoring centers, emergency services and telecommunications infrastructure." In a move to bring 5G technology to Argentina, current President Alberto Fernández visited Beijing's Huawei Technology Center in 2022. Initially, Argentina aimed to have 5G technology running by 2022 or 2023. While 5G tests have begun with Huawei, no official rollout has been announced.

Figure 7: Huawei and ZTE Offices in Buenos Aires, Argentina

CHINESE SECURITY LAWS POSE RISK TO SOUTH AMERICA'S DATA PRIVACY

In November 2022, the U.S. Federal Communications Commission (FCC) unanimously voted to ban the sales of all Chinese telecommunications equipment and devices manufactured by prominent brands such as Huawei and ZTE, citing the risk to national security.

The United States has since urged other countries, especially its allies, to follow suit, arguing that the penetration of Chinese telecom companies into foreign markets threatens the security of host nations and their allies. As such, the growing presence of Chinese telecom companies in Latin America is an issue of international contention.

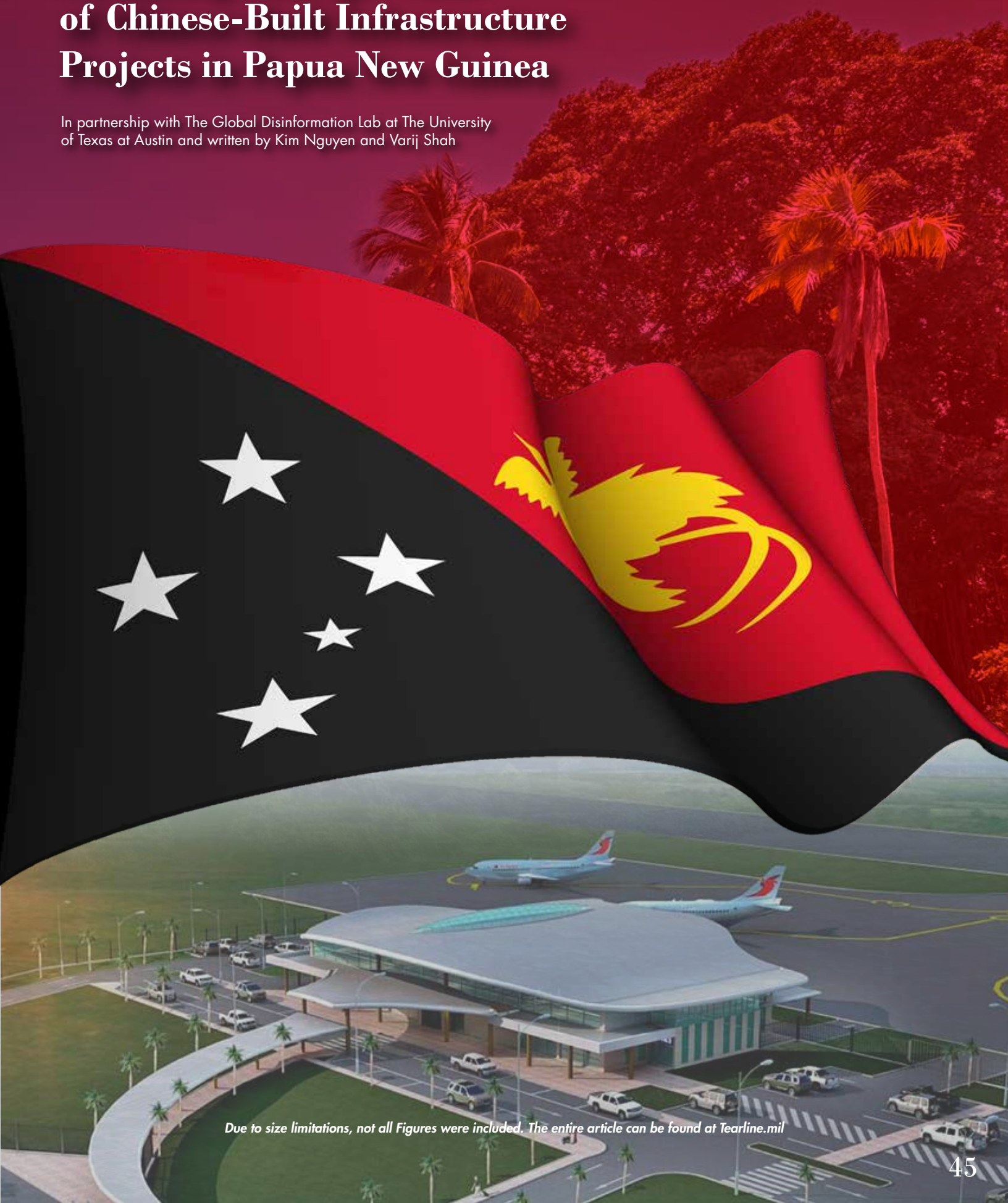
By the end of 2026, 5G is expected to represent around 43 percent of mobile subscriptions in Latin America, according to the Swedish telecommunications firm Ericsson. As Chinese companies increase their presence in telecommunications networks, their capability for data collection in the host country grows. While the country case studies included in this article have different histories with Chinese telecommunications companies, they all now have prominent 5G investments and capabilities. Though the United States has banned Chinese 5G tech, in other nations it has the potential to create a "digital iron curtain" between the United States and countries accepting Chinese help. As China seeks to assert its influence on the global stage through its Digital Silk Road, a key aspect of the Belt and Road Initiative (BRI), its influence over Latin American communications networks can be leveraged.

5G networks, for all their benefits, pose potential cybersecurity risks. Individuals, companies, and governments using Chinese 5G networks open themselves up to vulnerabilities that can be used to hurt the host country or to benefit China in a number of ways, including intellectual property theft, corporate and interstate espionage, and cyberattacks, including those against utilities grids and communications. Though the United States and its key allies have restricted Chinese 5G technology, the high functionality and low cost have helped growth, especially in lower-income countries. The proliferation of "cheap" Chinese 5G places these states at increased risk of Chinese espionage, intellectual property theft, and cyberattacks. While host states are the primary entities endangered by the use of Chinese 5G technology, the United States is exposed by roaming and network peering deals, as American facilities and American tourists in these host countries become exposed to network vulnerabilities – putting the transmitted data at risk of interception by the Chinese government.

As more countries allow Chinese telecom companies to gain access, China will develop deeper influence in the tech sphere and will gain stronger abilities to capture key information. In the broader context of US-China geopolitical tension over technology races, Latin American policymakers have often adopted a "pragmatic" and "neutral" stance balancing benefits from each alliance. However, in the cases described in this study, there is clear evidence of permitting 5G projects funded by China to flourish. This trend could pose a threat to the influence that the United States has maintained in the region for decades.

Analyzing Strategic Value of Chinese-Built Infrastructure Projects in Papua New Guinea

In partnership with The Global Disinformation Lab at The University of Texas at Austin and written by Kim Nguyen and Varij Shah



Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

Source: Copyright Maxar 2023

OVERVIEW

We assess that China is engaging and financially investing in development projects in Papua New Guinea to establish a stronger commercial presence and to potentially attain dual-use options in the South Pacific to counter Western influence in the region. This report covers two infrastructure projects in Papua New Guinea with Chinese activity: 1) the Momote Airport renovations and 2) the Ihu Special Economic Zone (SEZ) development.

Press reporting, business literature, social media, video data, and open imagery suggest Beijing's interest in widening China's economic footprint and obtaining potential dual-use options for infrastructure projects in Papua New Guinea. Yet, there are no current overhead imagery sources that illustrate Chinese military infrastructure or dual-use activity in Papua New Guinea at this time.

ACTIVITY

At Momote Airport, located only a short distance from the Papua New Guinean Lombrum Naval Base, a partially Chinese state-owned enterprise (SOE) extended the airstrip and installed a new terminal and airport apron. Due to recent defense agreements, the Momote and Lombrum sites are now open to the U.S. and Australian navies. Commercial ties to Momote Airport could potentially allow China to use its access to the facilities to collect intelligence on Western military activity. Although there are no open sources to confirm Chinese intelligence collection at Momote, there are potential concerns with base information passed back to China due to the 2017 Chinese National Intelligence Law, which obligates Chinese entities to provide intelligence to the People's Republic of China (PRC) in service to national security. Chinese "dual-use" at Momote is now unlikely given the recent agreement for the U.S. to use the base, but the history and context of Momote can help better understand more ambiguous Chinese commercial ventures such as the Ihu SEZ. At the Ihu SEZ, Beijing invested a significant amount of funding towards the project, which included general plans for a naval and military base along with several civilian economic sectors. Recent imagery illustrates the SEZ in the early stages of the project with the construction of poorly maintained roads and no clear development of a naval or military base. Aside from the disproportionate amount of Chinese financing of the SEZ, the PRC has not otherwise openly expressed interest in the bases. Furthermore, Papua New Guinean project officials have provided mixed messaging about committing to Chinese access to the future bases.

ARTICLE TIMELINE

On July 11, 2022, the Global Times, a Chinese state-owned newspaper, reported that the Chinese Embassy in Papua New Guinea refuted media claims that China's commercial projects in the country are aimed at military purposes. They stated that the media report was "completely baseless and hype with ulterior motives." In November 2022, the Papua New Guinea Prime Minister made a similar claim in a Bloomberg article, stating that "China has never expressed clearly their interest for a military base or presence of that nature in Papua New Guinea." Despite public denials, we assess that China is actively engaging and financially investing in development projects in Papua New Guinea to establish a stronger commercial presence and to potentially attain dual-use options in the South Pacific to counter Western influence in the region. Although some open-source reporting from groups like the Australian Strategic Policy Institute and United States Institute of Peace as well as indirect evidence, such as highly disproportionate funding at Ihu, suggest Beijing's potential interest in dual-use options for their projects in the South Pacific, there are no current imagery sources that illustrate Chinese military infrastructure or dual-use activity in place on Papua New Guinea at this time.

We have moderate confidence in our assessment based on commercial and publicly available satellite imagery and open-source reporting, including Papua New Guinea media outlets, Australian and U.S.-based articles, and social media. This piece acknowledges the inherent bias in certain state-run media outlets. The development projects we analyzed include improvements at the Momote Airport and the investment and construction of the Ihu Special Economic Zone (SEZ). Figure 1 illustrates the location of the two projects.

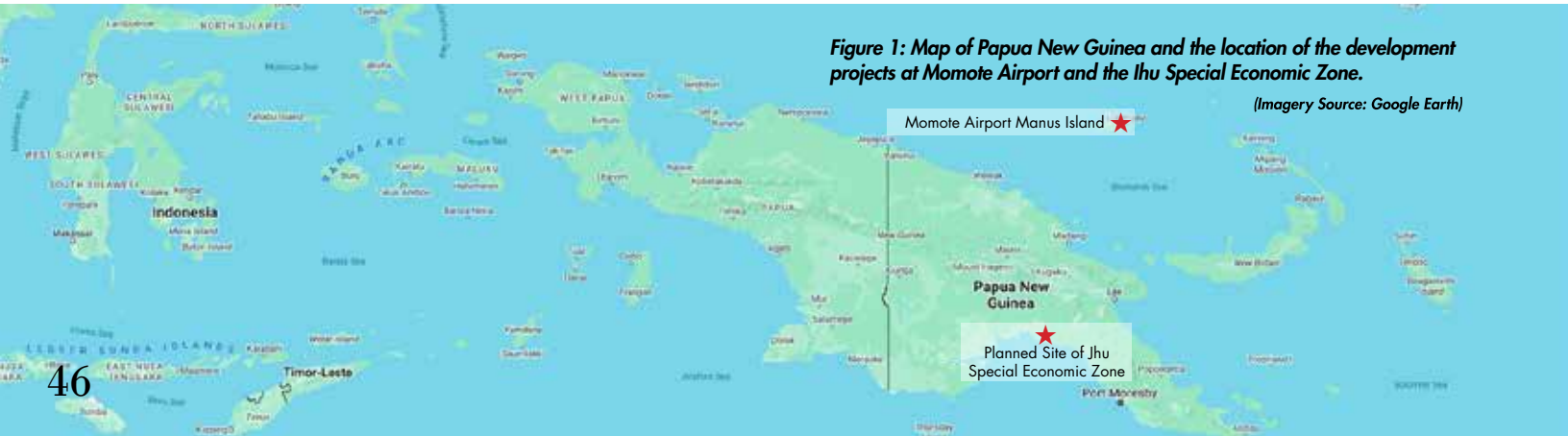


Figure 1: Map of Papua New Guinea and the location of the development projects at Momote Airport and the Ihu Special Economic Zone.

(Imagery Source: Google Earth)

BACKGROUND

In recent years, China has increasingly sought to compete with the U.S. and its regional ally Australia for influence in the South Pacific island nations, specifically in Papua New Guinea. Papua New Guinea is strategically located in the Indo-Pacific, offering a location that, in a conflict, would bolster Australia's maritime security and provide the U.S.-Australian coalition a way to project military power northward toward China and Southeast Asia. For China, the island's location gives it a potential avenue to control valuable sea lines of communication that lead to Australia's eastern coast and New Zealand.

In an effort to gain access to Papua New Guinea, China's outreach strategy has entailed engaging in infrastructure projects in the region. The locations of these projects engender a fear in Western defense circles that China's seemingly benign civil programs may have a "dual- use" capability. With the signed Defense Cooperation Agreement (DCA) between the U.S. and Papua New Guinea in May 2023, China's growing presence on the island may lead to increased tension with the U.S. and allies in the region.

On May 19, 2023, in response to a scheduled visit by U.S. Secretary Anthony Blinken to Papua New Guinea, the Chinese Foreign Ministry spokesperson Wang Wenbin shared China's opposition to the "introduction of any geopolitical games into the Pacific Island…"

Amid rising tensions between China and the U.S., Chinese activity and/or financial investment in two Papua New Guinean projects have received scrutiny due to the projects' strategic locations and their potential dual-use capacities. The first project, Chinese-led renovations at Momote Airport, sparked concern due to its proximity to the Lombrum Naval Base. Although Lombrum is owned by Papua New Guinea and is purposed for their vessels, the island nation has provided base access to the U.S. and Australian navies. Additionally, the recent DCA permits the U.S. military to use Momote Airport. The second project, the Ihu SEZ, deserves attention for several reasons: 1) the general plans to build a military and naval base, 2) its location near the Torres Strait, north of Australia, and 3) the disproportionate level of Chinese financial investment in the SEZ.

MOMOTE AIRPORT

In late 2016, the Asia Development Bank approved a plan to finance improvements at Papua New Guinea's Momote Airport. The airport is located on Manus Island, approximately 6 km (3.9 miles) southeast of Lombrum Naval Base (see Figure 2), which is operated by the Papua New Guinea Defence Force (PNGDF). Prompted by the rise of China and its more aggressive posture in the region, the U.S. and Australia endeavored to build and bolster Western influence in Papua New Guinea. In November 2018, former U.S. Vice President Mike Pence signaled support for the Lombrum Joint Initiative with Australia. The initiative supports the redevelopment of the base and builds the PNGDF's capability to protect its borders and maritime resources through mentoring, training, and infrastructure development at Lombrum. In late 2018, the Chief of the Royal Australian Navy stated that the redevelopment was "hugely important" to deepen ties with Papua New Guinea and added that Australian ships could visit the base for resupplying purposes. The West's efforts to increase cooperation with Papua New Guinea culminated in the signing of the 2023 DCA, which gave the U.S. military "unimpeded access" to both Momote Airport and Lombrum Naval Base.

Figure 2 – Map of Papua New Guinea's Momote Airport and Proximity to Lombrum Naval Base.

(Imagery Source: Google Earth)

In December 2016, China Harbour Engineering Company (CHEC), a partial Chinese SOE and a subsidiary of the China Communications Construction Company (CCCC), signed an agreement with Papua New Guinea's National Airports Corporation to provide improvements to the Momote Airport. It is important to note that the U.S. Commerce Department added CCCC to the "Entity List" on August 26, 2020, barring them from doing business with U.S. firms. The CCCC joined the U.S. "Entity List" for their role in helping the Chinese military construct and militarize the internationally condemned artificial islands in the South China Sea.

Official renovations at the airport began on September 8, 2017. The most noticeable developments included an extension of the airstrip, increasing the length from 1,810 meters (m) to 2,010 m (see Figures 3 and 4). According to satellite imagery, the CHEC completed the extension between January and March 2018. The length of the new airstrip can accommodate most commercial and military aircraft.

Accounting for weather conditions and weight, civilian aircraft such as the Boeing 737-700 and 737-800 and military aircraft such as the Chinese Y-20, a large military transport airplane, can take off and land at the newly renovated Momote Airport. Figure 5 illustrates the length of other airstrips in the Pacific, specifically in the South China Sea, and provides context for the Momote Airport airstrip and its corresponding aircraft capabilities. The Momote airstrip is larger than the airstrip at Malaysia's Swallow Reef (1,368 m) yet smaller than China's airstrip on Fiery Cross Reef (3,000 m). Figure 5 uses the South China Sea as context, but it is important to note that there is no evidence of Chinese military activity in Papua New Guinea in the same way as the South China Sea and that Momote is currently only being used for civilian airlines. The figure simply provides additional context.

Figure 3: The Momote Airport's airstrip measured 1,810 meters in length on January 7, 2018.

Figure 4: The Momote Airport's airstrip measured 2,010 meters in length on March 23, 2018.

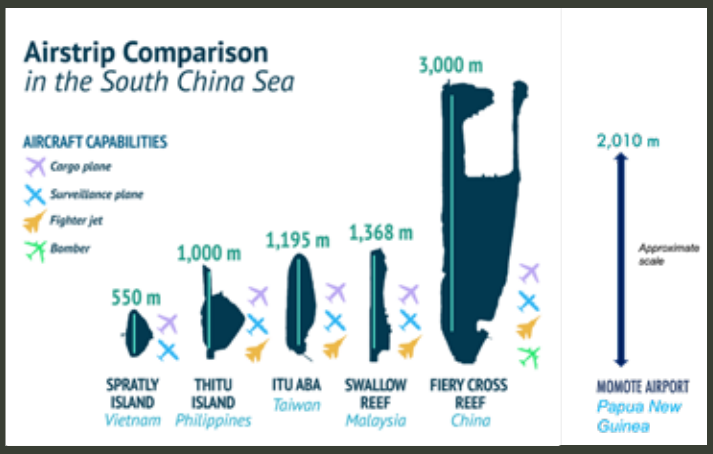


Figure 5: Airstrip Comparison in the South China Sea. As of March 2018, the new Momote Airport airstrip measured 2,010 meters.
(Source [Edited]: Asia Maritime Transparency Initiative)

Figure 6: Air Niugini's domestic flight paths with the four routes to and from Momote Airport highlighted in red. *(Source: Air Niugini)*

Figure 7: Chart illustrates the low level of air traffic at Momote Airport between July 20 and August 17, 2023, with the number of flights limited to one per day. *(Source: Flightradar24)*

Furthermore, Momote Airport exclusively services Air Niugini, the national airline of Papua New Guinea, with routes to four domestic airports, including the capital, Port Moresby (see Figure 6). Open flight data from July 20 to August 17, 2023 indicate that the airport had low levels of air traffic, operating up to one flight a day, according to data from Flightradar24, an online flight tracking service.

By April 2021, the CHEC completed the runway extension project and commenced building a new airport terminal. Additional renovations included a new airport apron, almost triple the size of the original apron, and precision landing aids on the runway (see Figures 8 to 10). By April 2022, the improved Momote Airport was completed and officially in operation, according to local Papua New Guinean news media. Figure 11 shows the Momote Airport as of July 2023, with no further developments at the date of publication.

Figure 8: Imagery from December 2012 illustrates the location of the original airport apron prior to the renovations and the sites of the future airport terminal and apron. The original size of the apron was 5,476 m².

Figure 9: Imagery from March 2021 illustrates the newly constructed runway apron as well as the construction site for the new airport terminal. The size of the new airport apron is 15,129 m², almost triple the size of the original apron (5,476 m²).

Figure 10: Imagery from July 2022 illustrates a completed airport terminal and airport apron in use by civilian airliners.

Figure 11: Imagery from July 2023 illustrates no further developments since July 2022 and little to no aircraft activity at Momote Airport.

The Momote Airport project, among others like it, provided Beijing an early entry point to become a major economic player in Papua New Guinea. The commencement of the airport renovations coincided with a time when Papua New Guinea was in political courtship with the PRC, which led up to the nation's official enlistment into the Belt and Road Initiative in June 2018.

Post-DCA, China's interest in Momote Airport remains unclear. China's objectives at Momote may have evolved over time with the changing geopolitical situation in the South Pacific. China's initial intentions for the project may have been for a civilian purpose to generate jobs and/or for military purposes. If the latter, the U.S. defense agreement with Papua New Guinea would appear strategically timed. As with the implementation of the DCA and the U.S. military use of the airport, it is unlikely that there will be any Chinese military activity at the site in the next 15 years – the duration of the agreement.

We face the question of whether CHEC continues to have any involvement or activity at the airport which may lead to potential intelligence gathering of Western military activity at Momote or the nearby Lombrum Naval Base. Under the 2017 National Intelligence Law, CHEC would be obliged to assist in intelligence collection on behalf of the PRC wherever it serves in the national security interest. We know that CHEC was the principal contractor for the project, and prime contractors are likely to be very competitive for future projects, such as upgrades and repairs, due to their command of the bidding process, technical expertise, and intimate knowledge of the airport specifications. This makes CHEC's return to the site likely if the airport requires further upgrades. According to an interview with a leading member of the Papua New Guinean Chinese business community, Chinese SOEs such as CHEC "enter the country to do a specific construction task, and then decide to stay on, and get selected for [jobs] because they fiercely undercut their competitors." In 2019, CHEC had 20 infrastructure projects in Papua New Guinea, according to an interview with a CHEC employee, and ADB confirmed that Chinese SOEs held contracts for over 80% of ADB-funded development projects in the country. Furthermore, CHEC is active at bridge and road construction projects in Papua New Guinea, including work at the Ihu SEZ. With CHEC's strong ties to Momote Airport and the company's solid competitiveness in the infrastructure business in Papua New Guinea, it would be wise to vet all CHEC, or any SOE, personnel doing future work at the airport given the more robust U.S. military presence on Manus Island.

By projecting its military influence at Momote and Lombrum, the U.S. may have upended Beijing's motivations for the airport and surrounding areas. However, the Momote Airport is not the only strategic location in Papua New Guinea in which the PRC sought to use its geoeconomic tools to secure a foothold. In our analysis of the next project, we observe Beijing's financial commitments in the construction of the Ihu SEZ, in a likely effort to expand its influence and to create potential dual-use opportunities in the South Pacific nation.

Figure 12: Satellite imagery of the Ihu SEZ area on March 22, 2021, prior to any PRC financial investment. *(Imagery Source: Sentinel-2 L2A)*

Figure 14: Conceptual design of the naval base in the proposed Ihu SEZ, according to the Kikori District's promotional video. Mandarin characters on the left bottom corner of the slide translate to "naval base."
(Source: Kikori District YouTube Channel)

Figure 15: Conceptual design of the military base in the proposed Ihu SEZ, according to the Kikori District's promotional video. Mandarin characters on the left bottom corner of the slide translate to "military base."
(Source: Kikori District YouTube Channel)

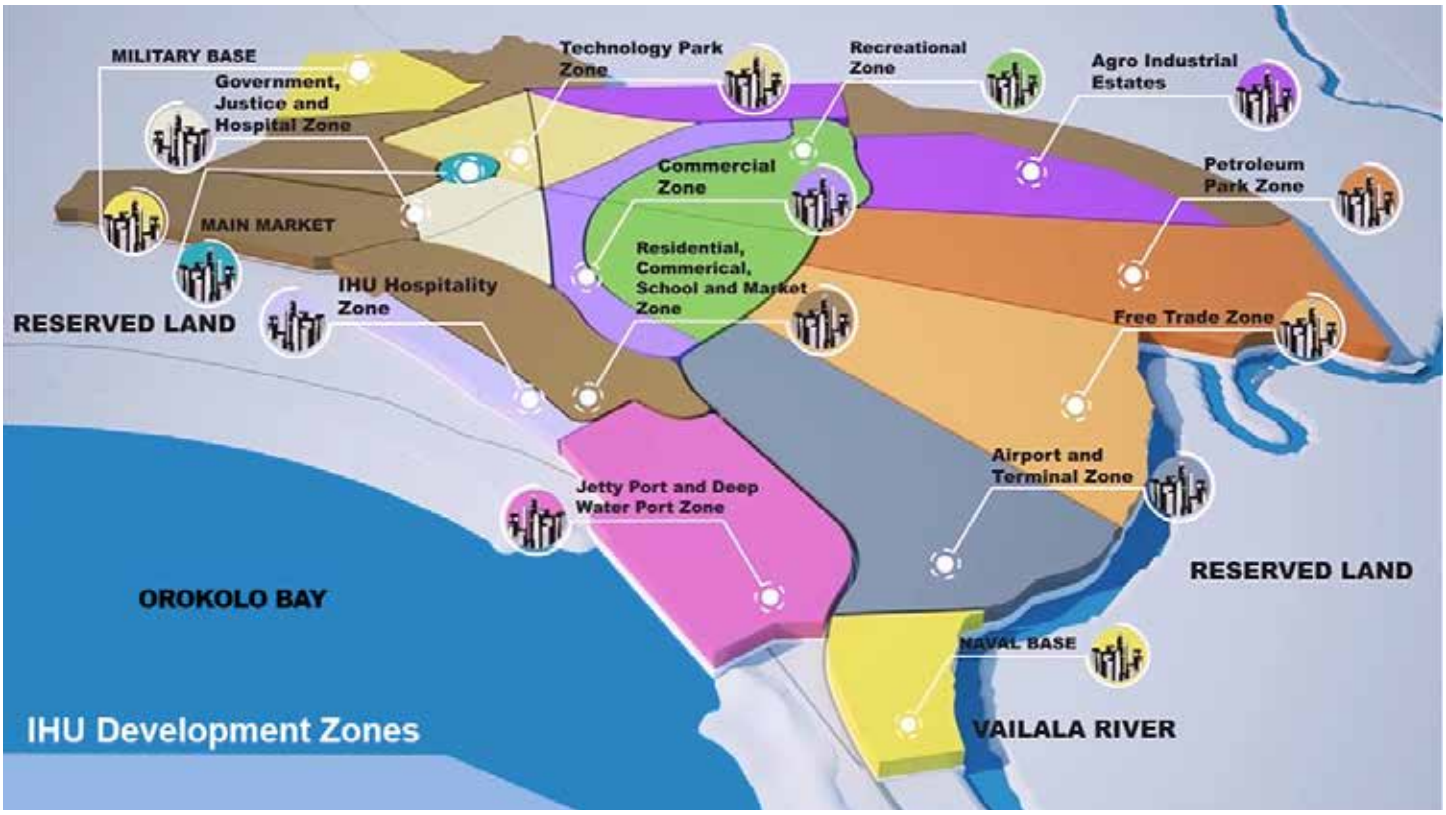


Figure 13: Proposed Ihu SEZ development zones in the Kikori District's promotional video. The naval and military bases are highlighted in yellow.
(Source: Kikori District YouTube Channel)

IHU SPECIAL ECONOMIC ZONE

The proposed Ihu SEZ is an 85,000-hectare development project located near the town of Ihu in the Kikori District, along the southern coast of Papua New Guinea (see Figures 1 and 12).

In 2019, during the initial phases of planning and securing funding for the project, the local Kikori District released a video promoting the Ihu SEZ in Mandarin and English text. The video included concepts for a naval and military base on the southern and northwestern edges of the SEZ (see Figures 13 to 15). From the presentation, it is unclear who the bases are for, but their inclusion is likely meant to appeal to Mandarin- speaking and English-speaking investors who might be interested in potential military access. As seen in Figure 13, the project also included proposals for other civilian zones dedicated to technology, petroleum, recreation, etc.

On September 24, 2021, the PRC committed a direct investment of 80 million Kina (K), or approximately 28.5 million USD, to the Ihu SEZ, which was used to kick-start the major access road development at the SEZ. In June 2022, the PRC committed to additional funding for the Ihu SEZ, bringing a welcomed early investment since the Papua New Guinea government reduced its original commitment from K100 million to K50 million. The government's revised contribution is scheduled for distribution over five years, equating to only K10 million per year, significantly reducing the available funds for the project. As of mid- 2022, China appeared to be the primary investor in the Ihu SEZ, providing more funding than the Papua New Guinea government.

During the early stages of planning, three Chinese SOEs: CHEC, PowerChina, and the China Steel CSCEC, signed agreements to provide technical support to the Ihu SEZ project. CHEC is the same company that completed the renovations at the Momote Airport.

According to local Papua New Guinean media, the government approved the use of the K80 million investment by the PRC to start road construction between Ihu and Purari (also known as Kaumea), a project entrusted to CHEC and commenced in April 2022. Publicly available satellite imagery from March and September 2022 (Figures 16 and 17 [top], respectively) corroborates the local media report, illustrating the time frame in which an unpaved road, trending northwest to southeast along the path between Ihu and Purari, underwent construction. In the comparison in Figure 17, the new road in the top image appears to correlate with the area originally proposed for a naval base and airport in the bottom image, cutting through the center of the SEZ. The conceptual design for the naval base includes an airstrip adjacent to the base facilities and, in the future, may potentially align with the strip of cleared land bearing northwest to southeast in Figure 17 (top). In the following six months, between September 2022 and March 2023, there were no observable additional developments (see Figures 17 [top] and 18), and the roads appear overgrown with vegetation. In imagery from July 2023, the roads are faintly visible (Figure 19).

Figure 16: Satellite imagery of the Ihu SEZ area on March 17, 2022, approximately six months after the PRC investment of K80 million. There is no visible road development.

Figure 17: Satellite imagery on September 18, 2022, one year after the PRC's initial K80 million investment in September 2021, illustrates visible unpaved roads in the area, which correlates with the proposed Naval Base and Airport (bottom). The strip of cleared land in the imagery (top) appears to align with the proposed airport location (bottom) and may potentially be the future airstrip.

Figure 18: Satellite imagery of the Ihu SEZ area on March 22, 2023. There is little to no additional development since September 2022. The new roads appear overgrown with vegetation.

Figure 19: Satellite imagery of the Ihu SEZ area on July 20, 2023. There is little to no additional development since March 22, 2023. The new roads are faintly visible.

The imagery from September 2022 illustrates that the Ihu project made progress on road construction within a year of initial PRC financial investments, especially after Chinese Foreign Minister H.E. Wang Yi publicly made additional commitments to fund the Ihu SEZ in June 2022. Yet, the project may be experiencing some recent setbacks with road maintenance, as exemplified by the visible vegetative overgrowth in March and July 2023.

Unlike the Momote Airport, the Ihu SEZ project had explicit references to military use, as evidenced in the initial project proposals. Since the construction of the SEZ is still underway with signs of delays such as vegetation overgrowth on the roads, it is unclear whether the proposed naval and military bases will come to fruition. It is possible that the proposals were included merely to attract Chinese investment. In an Australian 60 Minutes interview in July 2022, the Ihu SEZ Project Director stated that if the Chinese "increase the amount of support they are giving…in the military space, then they might pick up those two bases," referring to the proposed naval and military bases. The use of the term "pick up" may have implied that China would gain ownership or access to the two bases. This recorded comment, cast for Australian audiences, may have also been intended for Beijing, as it occurred in July 2022, one month after the PRC committed to additional funds for the SEZ. However, in response to public comments on his LinkedIn account expressing concern about a Chinese military base in Papua New Guinea, the Project Director walked back his previous statement. As shown in Figure 20, he stated that the "Ihu SEZ military bases will be for the PNGDF, not for Australia or China to fight over."

It remains uncertain whether the proposed naval and military bases will be constructed and, if so, whether Papua New Guinea will permit access to China. Nevertheless, as the success of the project appears heavily dependent on Chinese funds, Beijing will likely have some influence on the project's plans and priorities.

CONCLUSION

China's recent and future involvement in Papua New Guinea's infrastructure projects should be cause for concern. The West has openly signaled its desire for military influence in Papua New Guinea, which can be seen in the signing of the DCA. In contrast, Beijing has been dismissive about its military interests in the country although its undertakings and economic investments include civilian infrastructure projects that have the potential to be used for military purposes such as the budding Ihu SEZ project.

The PRC could leverage CHEC's project ties to Momote Airport to potentially gather intelligence on U.S. and Australian forces at the airport or the nearby Lombrum Naval Base. It is difficult to confirm CHEC's continued involvement at the site and if the entity will send intelligence back to Beijing like in other situations animated by the 2017 National Intelligence Law. In the likely case that CHEC, who is a major infrastructure developer on the island and was the contractor during the airport renovations, will be present at the airport for future repairs or upgrades, it is important to screen contractors operating on the facility to minimize risks to Western militaries present in the area.

Water Management Policy in Afghanistan After the Fall of the Afghan Government

Written by Erin Horrigan, Garrison Goetsch, Anna Glass, Zoe Roberts, Yasha Barth, Lilly Doninger, Kaitlyn Wilson and Aliia Woodworth from College of William & Mary

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

OVERVIEW

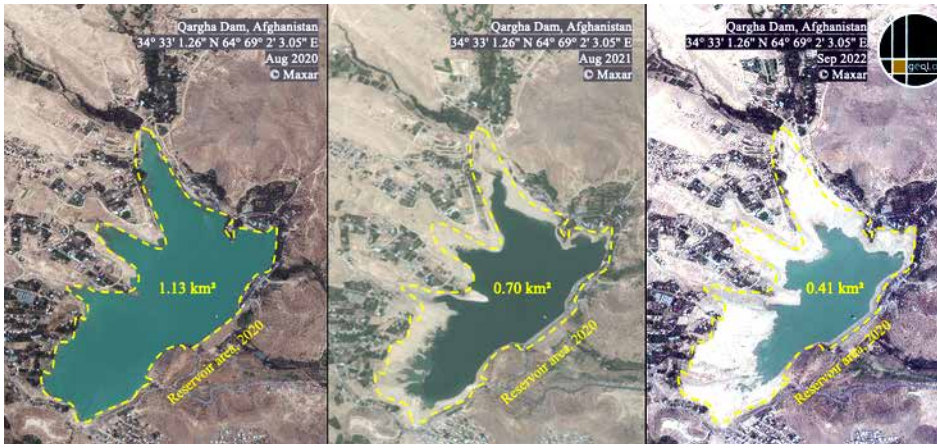
Afghanistan is facing an intensification of extreme weather events and natural disasters, including droughts, floods, storms, and landslides, according to British humanitarian and development NGO, Afghanaid. The frequency of droughts in Afghanistan has doubled since the late 20th century, causing significant impacts on farmers, livestock, and crops, reducing food supply to alarmingly low levels, as reported by the UN Office for the Coordination of Humanitarian Affairs (UN OCHA).

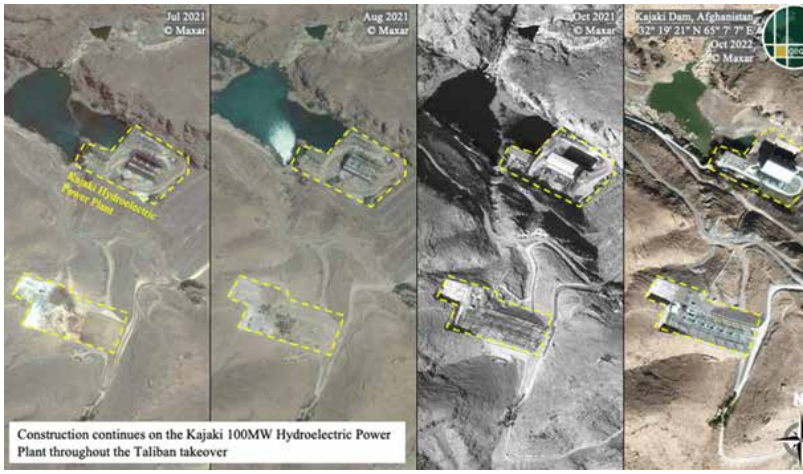
Due to hesitancy of global climate organizations such as the United Nations Climate Change Conference to include the Taliban in the climate dialogue and a lack of climate adaptation funding, the situation will likely continue to worsen. According to the 2021 Global Climate Risk Index, Afghanistan is the sixth most impacted country of climate change related disasters; it also suffers from economic instability and a humanitarian crisis.

The situation is dire. The World Food Programme reports that, as of September 2021, only one in twenty Afghans were getting enough to eat. In the last year, 6 million people's lives were put at risk due to a lack of food. A 2021 drought caused wells to run dry, dramatically decreasing irrigation abilities, according to the UN OCHA, which only worsened the food crisis. The same drought also decreased hydropower outputs, causing the Kajaki Hydroelectric Power Plant's production to drop by 85%.

Drought and flooding are interlinked in Afghanistan. The intensification of flooding can be attributed to preceding droughts, as dry, drought-stricken soil leads to increased runoff and exacerbates flood risk. The summer of 2022 saw severe flooding, resulting in hundreds of fatalities and widespread damage. According to the Afghanistan National Disaster Management Authority, 16,000 homes were destroyed and a quarter million Afghans were displaced.

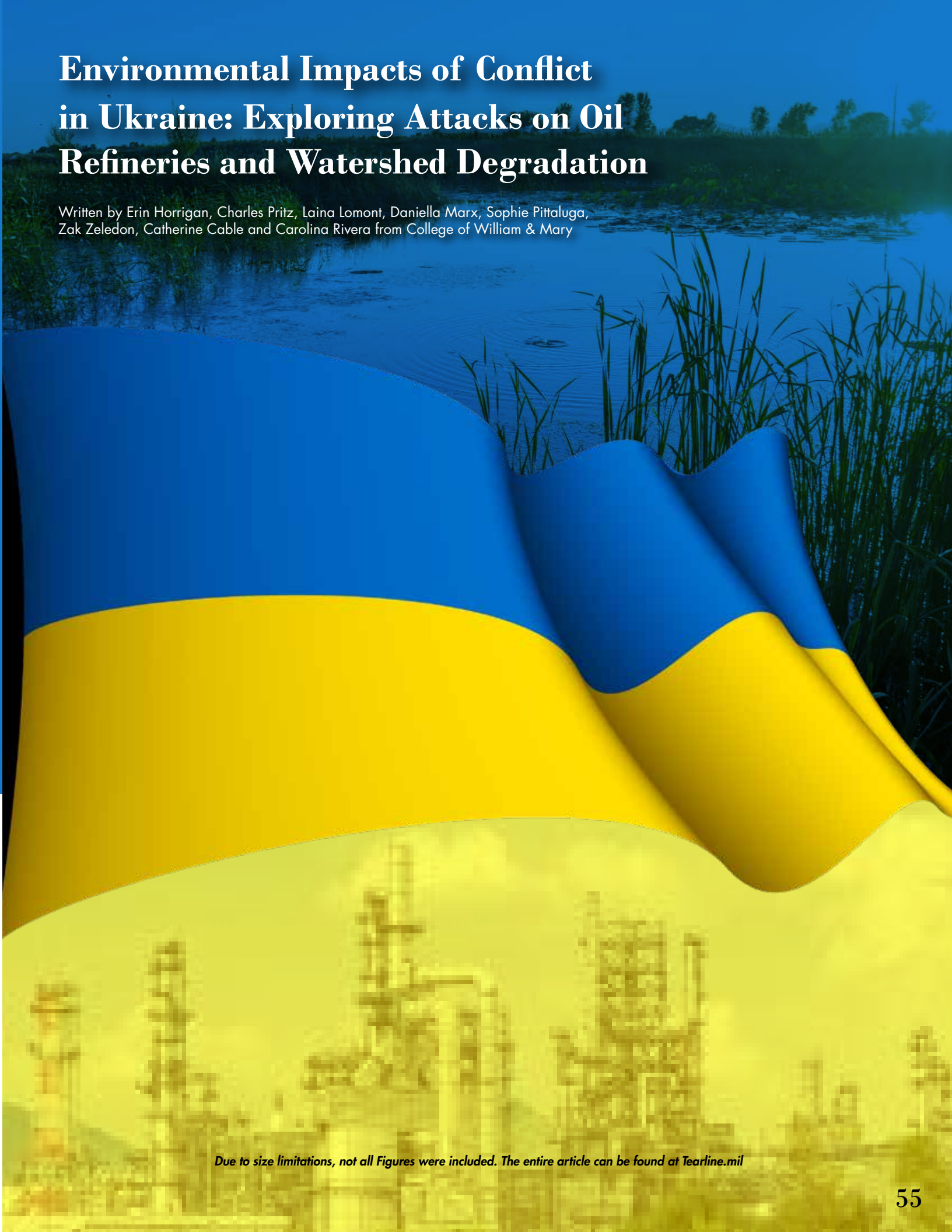
The root cause of the water crisis in Afghanistan is unique in that it is not a shortage of water resources. Afghanistan is rich in water, with a total of 75 billion cubic meters available. This abundance of water resources also supports neighboring countries. Instead, the intensity of Afghanistan's droughts are primarily a result of inadequate hydrological infrastructure, decades of infrastructure damage during war and political instability, and institutional failures in water management practices.





Environmental Impacts of Conflict in Ukraine: Exploring Attacks on Oil Refineries and Watershed Degradation

Written by Erin Horrigan, Charles Pritz, Laina Lomont, Daniella Marx, Sophie Pittaluga, Zak Zeledon, Catherine Cable and Carolina Rivera from College of William & Mary

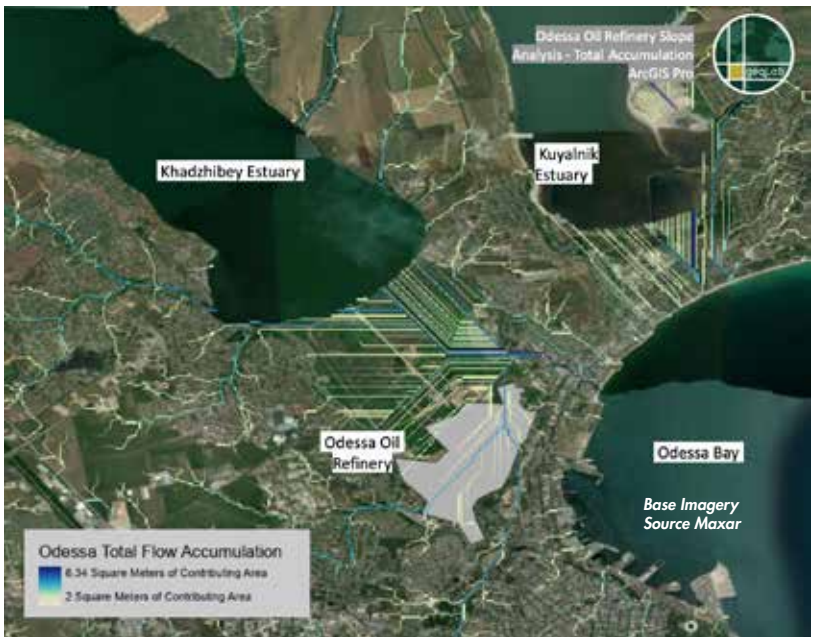


Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

OVERVIEW

The Russian invasion of Ukraine presents potential environmental consequences. Since early 2022, Russian forces have attacked multiple oil refineries across the country. Watershed analysis indicates that contamination from these attacks could pollute lands, groundwater, and seep into nearby surface waters.

Geospatial analysis of the Kremenchuk and Odessa Oil Refineries - which have both been targeted by Russian attacks and are situated near major waterways - reveals potential environmental degradation specifically in the surrounding areas, with the possibility of disruptions to human health and agricultural lands. This analysis can serve as a long-term impact model, or partial model, for future oil or other chemical storage attacks in other regions.



Impacts to Cultural Heritage in Ukraine

Written by Kate Harrell, Damian Koropeckyj, Kaitlyn Fitzgerald, Abigail Maher, Ella Mints, Madeleine Gunter-Bassett, William Welsh and Hayden Bassett from Cultural Heritage Monitoring Lab (CHML)

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

OVERVIEW

This report summarizes confirmed impacts to cultural heritage sites due to the ongoing armed conflict in Ukraine from September 2022 through January 2023. Confirmations were made by the Cultural Heritage Monitoring Lab (CHML), using high-resolution commercial satellite imagery supplied by CHML's partnership with NGA. In total, CHML analysts confirmed conflict-related impacts to 102 Ukrainian sites between September 1, 2022 and January 31, 2023, for a total of 309 since February 24, 2022.

ACTIVITY

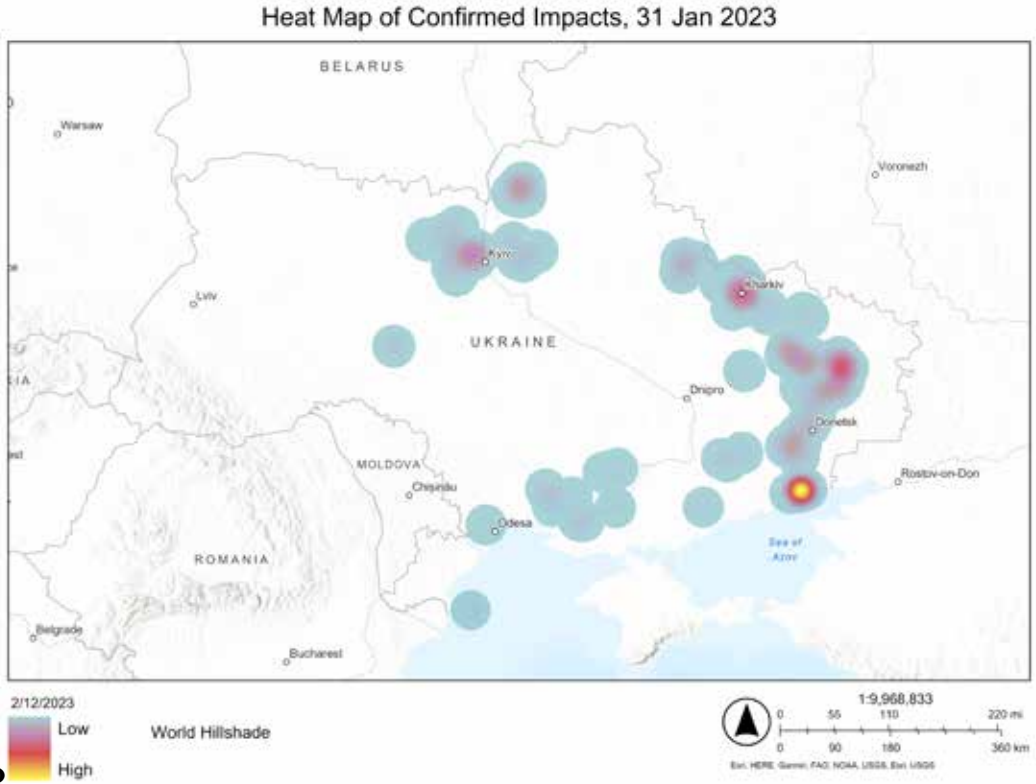
The Cultural Heritage Monitoring Lab (CHML), a partnership between the Virginia Museum of Natural History (VMNH) and the Smithsonian Cultural Rescue Initiative (SCRI), uses open-source research, remote sensing, and high-resolution commercial satellite imagery to identify and monitor cultural heritage sites that are threatened by armed conflict or natural disaster. Cultural heritage sites include, but are not limited to, archaeological sites, monuments, memorials, places of worship, museums, archives, libraries, cultural centers, and cemeteries. CHML maintains a geospatial database of over 28,000 Ukrainian cultural heritage sites, including sites in eastern Ukraine and Crimea. CHML's Ukraine database was developed in April 2021 and has been used to monitor conflict-related impacts to Ukrainian sites since February 2022. This report is the third in a series of confirmed impact reports. The data presented here represent confirmations made by CHML analysts between September 1, 2022 and January 31, 2023, and do not necessarily represent impacts that occurred between September 1, 2022 and January 31, 2023. All impacts occurred from February 24, 2022 onwards.

Definitions

Lead: A lead designates an unconfirmed, open-source report that a cultural heritage site has been damaged. It serves as a starting place for further investigation rather than a confirmation of damage. Common leads include social media posts, single-source interviews, and unconfirmed news reports. Leads are used as tips for queuing further investigation via satellite imagery (i.e., "tip and queue").

Potential Impact: A potential impact designates a cultural heritage site that is located close to remotely-sensed kinetic activity (see below for a discussion of CHML's use of NASA FIRMS) and may have sustained damage as a result of that kinetic activity. Like leads, potential impacts are used as tips for queuing further investigation via satellite imagery (i.e., "tip and queue").

Confirmed Impact: Leads and potential impacts are re-classified as confirmed impacts when additional, independent strands of intelligence provide evidence that sites have indeed been impacted. Most impacts are confirmed through the identification of damage in satellite imagery; however, a small number of confirmations are made based on multi-sourced news and social media reports.



Methodology

CHML maintains a database of over 28,000 Ukrainian cultural heritage sites, including sites in eastern Ukraine and Crimea. This Ukrainian cultural heritage site database was derived in part from a scrape of open-source data (OpenStreetMap). Although new sites are regularly added to the dataset, there are some notable omissions, including municipal buildings that are also historic structures and Soviet-era monuments that were recently removed by the Ukrainian

Figure 1: Heat map of confirmed impacts in Ukraine through January 31, 2023.

government (e.g., the "Monument to the Founders of Odesa," which was dismantled on December 28, 2022). The categories of cultural heritage sites included in the database were taken from the Cultural Heritage Site List (CHSL) data standards, which were developed by the Penn Cultural Heritage Center (PennCHC) at the University of Pennsylvania Museum with National Science Foundation funding (Grant #1439549).

Monitoring of sites in the database occurs every ~48 hours, during which time remote fires sensing data released by NASA FIRMS is pulled and overlaid on the inventory GIS layer. Sites that overlap with FIRMS "hot spots" are then classified as potential impacts. CHML analysts review commercial satellite imagery of each newly classified potential impact to identify whether it has visible signs of site/structure damage. Potential impacts with visible site/structure damage are then reclassified as confirmed impacts. There is a time lag inherent in the confirmation process due to satellite periodicity, but this lag is a matter of hours or days, meaning that CHML can report confirmed impacts within 72 hours of a kinetic event.

Research via open-source outlets (i.e., social and news media) provides additional information about sites that are marked as potential impacts, as well as leads about sites that are not marked as potential impacts. Leads are geolocated so that they can be queued for confirmation via commercial satellite imagery analysis. In cases where leads document damage to a site that is not visible in commercial satellite imagery, sites usually remain unconfirmed. However, in a small number of cases, such as Russia's seizure of Potemkin's remains and other antiquities from Kherson, confirmations are made based on a combination of multi-sourced news, social media reports, and Russian reporting. The conservative nature of CHML's approach means that confirmations should be taken as a minimum number of confirmed impacts.

Operational Security Note

Highly detailed and precisely geolocated cultural heritage site data are not included in this study for operational security purposes. However, abstracted and aggregated analyses have value to show broad trends and categories.

Key Findings with Heat Map Visualization and Tables

This streamlined confirmed impact report presents data generated between September 1,2022 and January 31, 2023. Data presented in this report have compositional and distributional similarities to data presented in CHML's previous confirmed impact reports (here and here). Cultural heritage sites that are commonly found in urban areas (e.g., places of worship, art centers, museums, libraries, and memorials) continue to sustain the most observed damage. This trend will likely persist as civilian infrastructure continues to be targeted. As noted in previous reports, there are inherent resolution problems in the satellite imagery confirmation process. CHML's confirmed impacts likely overrepresent larger sites and structures and underrepresent smaller sites with less visible footprints, such as memorials and monuments. Additional confirmation methods must be used to determine if damage has occurred to these small-footprint sites.

Site Type	Number of Sites	% of Confirmed Impacts
Place of Worship	123	39.8%
Arts Center	37	12.0%
Historic Structure	49	15.9%
Library	31	10.0%
Museum	18	5.8%
Memorial	18	5.8%
Conservatory/Concert Hall	7	2.3%
Monument	11	3.6%
Theater	3	1.0%
Archaeological Site	1	0.3%
Cemetery	1	0.3%
Other	10	3.2%
TOTAL:	**309**	**100.0%**

Table 1: Total confirmed impacts to cultural heritage sites in Ukraine through January 31, 2023.

Site Type	Number of Sites	% of Confirmed Impacts
Place of Worship	25	24.5%
Arts Center	11	10.8%
Historic Structure	26	25.5%
Library	14	13.7%
Museum	2	2.0%
Memorial	6	5.9%
Conservatory/Concert Hall	2	2.0%
Monument	6	5.9%
Theater	0	0.0%
Archaeological Site	0	0.0%
Cemetery	0	0.0%
Other	10	9.8%
TOTAL:	**102**	**100.0%**

Table 2: Total confirmed impacts to cultural heritage sites in Ukraine September 1, 2022 through January 31, 2023.

North Korea's Tourism Industry: A Grand Initiative in Limbo

In partnership with Stimson/38 North and written by Peter Makowsky, Jenny Town, Iliana Ragnone, and Ryan Kleissler

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

OVERVIEW

North Korea's tourism industry took a major hit in 2020 when the pandemic forced the country to close its borders. Once high-profile construction projects, such as the Wonsan-Kalma Beach Resort, were effectively halted as priorities shifted toward domestically oriented projects. Despite a slow reopening to trade in 2022, activity at the North's key tourist sites remains largely unchanged.

It may still be a while before foreign visitors are allowed back into the country, especially at pre-pandemic levels. Stepped-up attempts to finish major tourist projects could provide some indication of when that is expected. However, at this time, the resorts that were open before 2020 appear to still be in operation, but those that were under construction are no closer to opening.

North Korea's Animal Protein Farming: Expansion Status and Challenges

In partnership with Stimson/38 North and written by Peter Makowsky, Jenny Town, and Iliana Ragnone

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

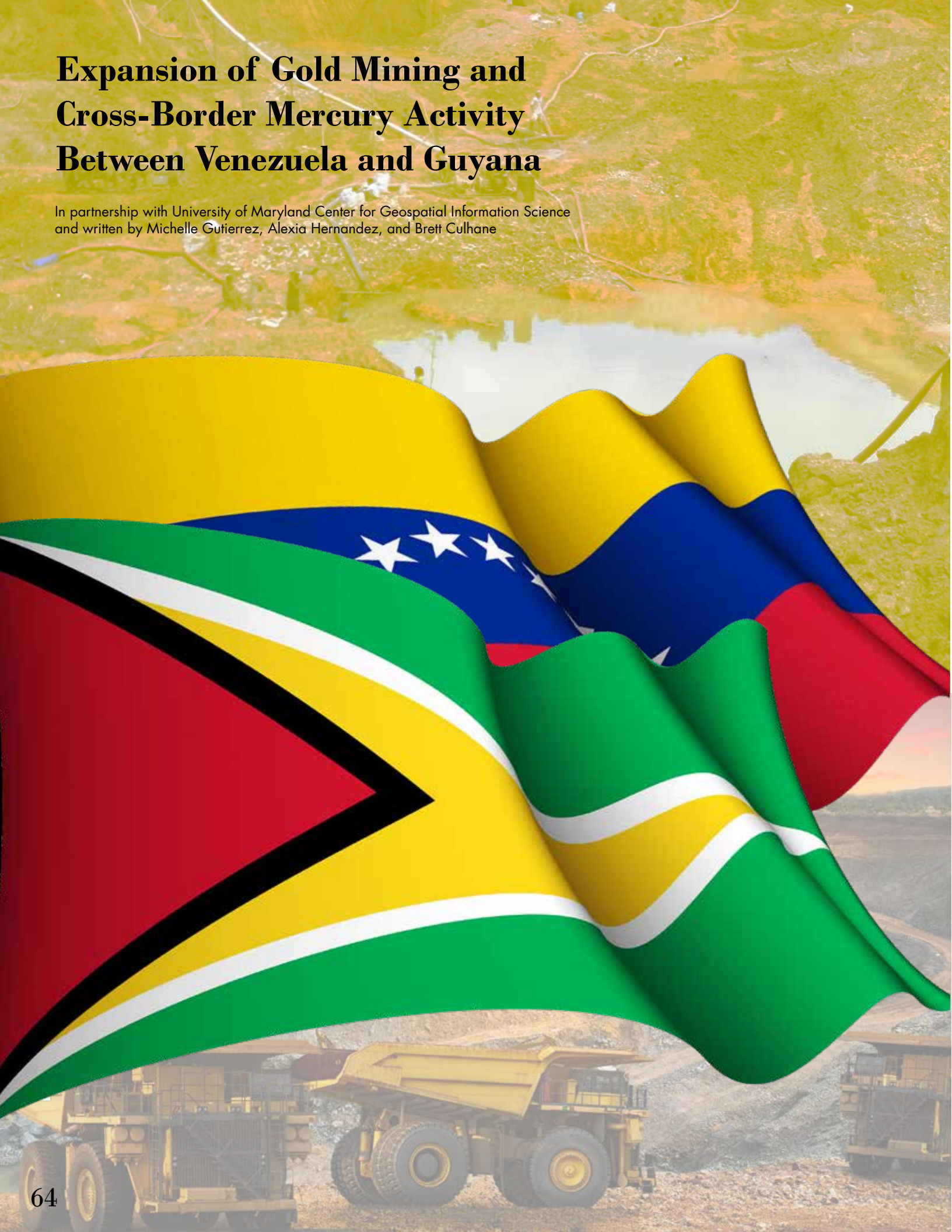
OVERVIEW

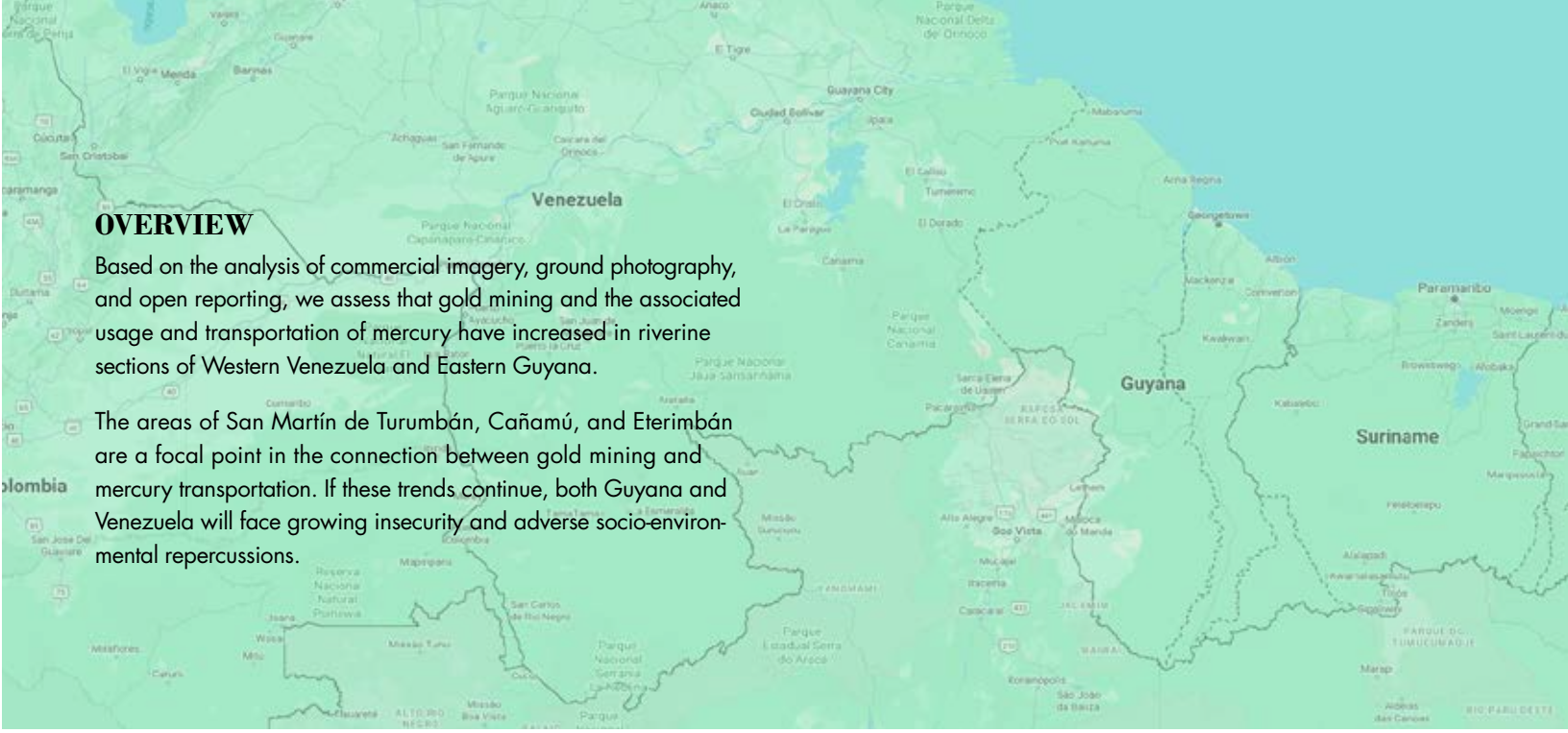
Trying to assess the food situation in North Korea is a perennial discourse, with chronic shortages reported each year. In normal years, humanitarian aid and the import of foodstuffs help supplement domestic production, making shortages less pronounced, especially for those who have access to markets and income to spend. Moreover, imports of agricultural products such as seeds and fertilizers help increase the resiliency of domestic farming against increasingly unpredictable and sometimes extreme weather conditions. However, since the country's self-imposed pandemic isolation, domestic food production has become more important. The lack of major imports and assistance since 2020 has raised serious concerns over food security in North Korea and the potential for a humanitarian crisis.

While cereals and grains are a major focus of food assessments in North Korea, protein sources are an equally important part of the equation. Prior to 2000, except for North Korea's elites, the country subsisted principally on vegetarian diets. To have meat as few as two to three times a year was the apparent norm. Under Kim Jong Il, that began to change as efforts to expand the availability of animal protein to more of the population began around 2005. Under Kim Jong Un, there has been an even greater emphasis on animal husbandry, including poultry, pig, rabbit, and larger grazing animals such as sheep, goats, and cattle.

Expansion of Gold Mining and Cross-Border Mercury Activity Between Venezuela and Guyana

In partnership with University of Maryland Center for Geospatial Information Science and written by Michelle Gutierrez, Alexia Hernandez, and Brett Culhane





OVERVIEW

Based on the analysis of commercial imagery, ground photography, and open reporting, we assess that gold mining and the associated usage and transportation of mercury have increased in riverine sections of Western Venezuela and Eastern Guyana.

The areas of San Martín de Turumbán, Cañamú, and Eterimbán are a focal point in the connection between gold mining and mercury transportation. If these trends continue, both Guyana and Venezuela will face growing insecurity and adverse socio-environmental repercussions.

ACTIVITY

We used a medium-sized data sample and case study of San Martín de Turumbán, Cañamú, and Eterimbán to illuminate broader imagery and land cover mining trends in riverine sections of Venezuela and Guyana such as mining expansion and mercury usage and transport. For example, imagery analysis shows expanding gold mining activity in the form of mining pits and tailing ponds at San Martín de Turumbán between 2016 and 2023. In addition to site and facility-level imagery analysis, we performed a land use and land cover (LULC) change analysis at 13 mining sites situated along the Venezuela-Guyana border between 2008 and 2022 to examine the extent of mining activity expansion. The LULC change analysis reveals an expansion of mining activity across all mining sites.

The relationship between Guyana and Venezuela is particularly volatile due to the long-standing border dispute over the Essequibo Territory, an area spanning approximately 149,500 square kilometers that falls within Guyana's borders but is claimed by Venezuela. SOS Orinoco, an advocacy group focused on highlighting human and environmental concerns in Venezuela, reports that activities linked to the designated Orinoco Mining Arc, an area nearly the size of Portugal dedicated to mineral extraction, have been spilling over into neighboring regions. Furthermore, the report highlights the presence of organized armed groups (OAGs) in Essequibo Territory's mining areas, originating from Venezuela's Bolívar state and using the Cuyuní River as a route. These OAGs exert control over illegal mining, smuggle mercury to boost gold mining efforts and escalate tension along the Venezuela-Guyana border. This endangers Guyana's sovereignty and bolsters Venezuela's territorial claims in the Essequibo Territory. OAGs also manage river routes connecting Venezuela's eastern region with Essequibo and run "informal" checkpoints for profit, relying on illegal cross-border trade, including mercury and gasoline, which further fuels territorial disputes in the region.

Despite Guyana ratifying the Minamata Convention in 2014, a global initiative to reduce the use of mercury in mining, it has become the main source of mercury for many South American countries. According to Raphael Trotman, the former Minister of the Environment in Guyana, once mercury enters the country, there are no restrictions on its trade or movement. The unrestricted flow of mercury throughout Guyana facilitates the transportation of this substance to neighboring countries. On the other hand, Venezuela signed the Minamata Convention in 2016, but it did not reach ratification. Therefore, alongside other countries, Venezuela has established itself as a mercury trafficking destination due to its proximity to Guyana.

Liquid mercury is used in gold mining to form an amalgam with gold, which is then heated and vaporized to acquire the gold. Small-scale miners often choose to use mercury due to its simplicity, cost-effectiveness, and ability to capture fine gold particles, despite the associated environmental and health risks. In 2019, a U.S. Senate hearing addressed the issue of illegal mining in Latin America, highlighting human rights concerns with a particular focus on the use of mercury and its various negative impacts. During the hearing, while discussing Bolivar State in Venezuela, Carrie Filipetti, Deputy Assistant Secretary of Western Hemisphere Affairs, stated that "a test performed in mining communities recently showed that over 90 percent of people working in the mines in Bolivar had unsafe concentrations of mercury in their urine."

GOLD MINING LEGALITY AND CRIMINAL ASSOCIATION

The legal status of mining activities in the Orinoco Mining Arc is a complex and controversial issue. The term "illegal" is often applied by organizations and groups critical of Venezuelan President Maduro's human rights and environmental record, autocratic behavior, and use of state assets to legitimize corruption and criminal elements engaged in gold mining, transport, export, and sales. President Maduro created the Orinoco Mining Arc in early 2016 through emergency economic powers despite the National Assembly rejecting the economic decree.

Venezuela's Supreme Court reinstated the decree allowing Maduro to bypass constitutionally mandated environmental and indigenous community impact assessments. While Maduro's executive decree is the legal basis for mining within the Orinoco Mining Arc, international organizations and advocacy groups cite the disregard for Venezuela's Constitution, human rights violations, and immense environmental degradation as the reasons for the illegality of mining.

In addition to the legal controversy surrounding mining activities, there is widespread criminal activity around gold mining operations, especially within the Orinoco Mining Arc and our case study area. The Center for Strategic and International Studies (CSIS) noted the Mining Arc's high presence of criminal activity, "where armed non- state actors and local gangs compete for control of key mining operations." Additionally, the area of our study is noted by locals as having a substantial criminal presence with camps along the road route to San Martín governed by the Colombian National Liberation Army (ELN).

AREA OF INTEREST

According to multiple sources (see aggregated source link), mercury transportation along the Venezuela-Guyana border has been prevalent between three settlements: San Martín de Turumbán in Venezuela and Cañamú and Eterimbán (also known as Etheringbang) in Guyana. The terms "Eterimbán" and "Etheringbang" are used interchangeably throughout this report. According to InfoAmazonia, "a network of journalists who investigate the main environmental issues in the nine countries of the Amazon", Cañamú is an informal settlement established in the Essequibo Territory, with the name made up by the locals.

On-the-Ground Reporting Linked to Placenames

A substantial basis of our analysis is linked to on-the-ground reporting from three credible sources: InfoAmazonia, Grey Dynamics, a London-based private intelligence company, and International Crisis Group, an international non-profit focused on conflict prevention. The quotes below with highlighted placenames (geolocated) set the tone for much of our further analysis and expanded imagery work:

Grey Dynamics, "Illicit Mercury Market: Guayana´s Case," September 2021

While Mercury in Etheringbang is sold between 8-14 grams of gold per kilogram of mercury, in Ciudad Guayana miners are charged 25 grams per kilogram of impure mercury.

InfoAmazonia, "Mercury, Chasing the Quicksilver," September 2020

The economy of San Martín de Turumbán works like the neighboring Etheringbang. On the shore of the Cuyuní, there are dredges that dig into the earth in search of gold and carve out holes, as if a gigantic spoon had penetrated the riverbanks for several meters.

Guyana's mercury has been cheaper in Eterimbán for a few months due to the opening of an air route to Georgetown.

You can buy mercury with no restrictions in any bodega in Eterimbán.

Guyana's mercury mainly pollutes the waters of the mines near San Martín de Turumbán.

From the town's ramshackle boat dock you can see Cañamú, the hamlet where the miners usually buy the mercury used here.

International Crisis Group, "Troubled Waters along the Guyana-Venezuela Border," October 2019

The main currency in Etheringbang is gold. At the convenience stores, the prices are even denominated in it – 0.2g for a big jar of Nescafé, 0.3g for peanut butter. The town is far from any bank dispensing Guyanese dollars; the more readily available Venezuelan bolívar is nearly worthless, given the hyperinflation across the river.

International Crisis Group, "Gold and Grief in Venezuela's Violent South," November 2018

According to a former senior ELN figure, the group has been active in the disputed border area between Venezuela and Guyana for about ten years. They control two river routes used for smuggling into Guyana from San Martín de Turumbán and five nearby mines.

Figure 1 below delineates the region of interest in this study with an emphasis on the three primary sites as potential mercury transport areas and the other mines under study. Due to the absence of regulatory oversight in Cañamú and Eterimbán, there exists an unregulated environment where mercury can be purchased or sold at local establishments.

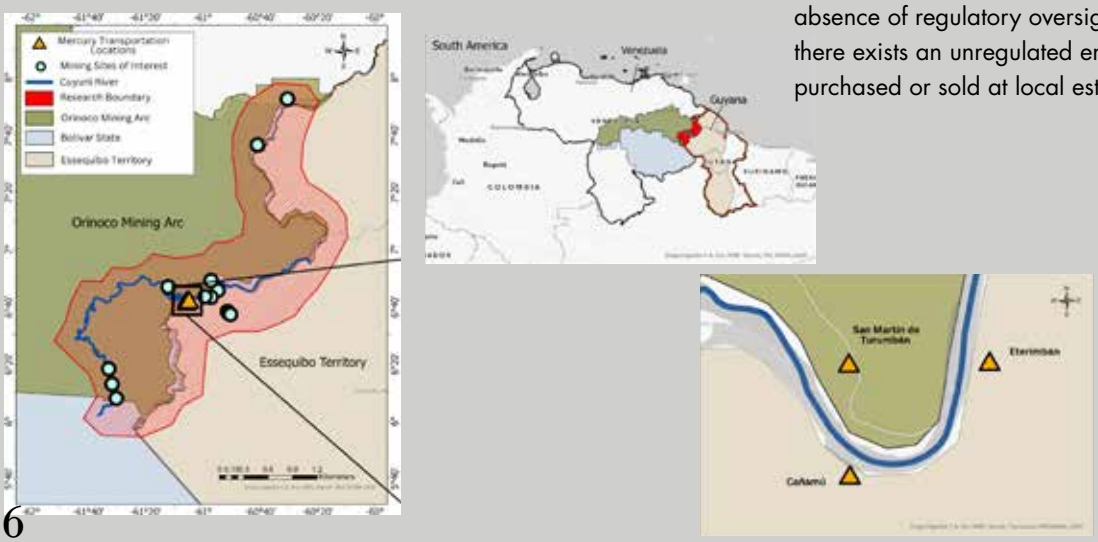


Figure 1: This map depicts the mining sites of interest for this research along the Venezuela-Guyana border. A focus is on San Martín de Turumbán, Cañamú, and Eterimbán for the case study yet highlighting the broader mining activities. Original Work, UMD students. Layers derived from Humanitarian Data Exchange, excluding areas of interest.

POTENTIAL GOLD MINING IN THE STUDY AREA

Figure 2 shows mineral areas in the Orinoco Mining Arc as identified by the Bolivarian Republic of Venezuela and depicts the planned surface for mining production in the Orinoco Mining Arc, with Area 4 marked as the area designated for gold mining with proximity to our study area geologically. For reference, "oro" is Spanish for gold. Figure 3 shows the presence of gold and gold mining sites within our study area, as identified by the Guyana Geology and Mines Commission.

Artisanal and small-scale gold mining (ASGM) involves the removal of aboveground biomass and the processing of alluvial soil sediments for the retrieval of minute historical deposits of gold particles. This type of artisanal alluvial mining has been historically practiced in the rivers south of the Orinoco by local and indigenous communities. Characteristics of this type of mining include small mining pits, small tailing ponds for mining site waste, trenches, and channels to access gold-bearing sediment, and discoloration of surrounding waters due to sediment runoff. Satellite imagery analysis can reveal these features. We have supplemented Figures 2-3 with suspected gold mining imagery signatures for all mining sites examined.

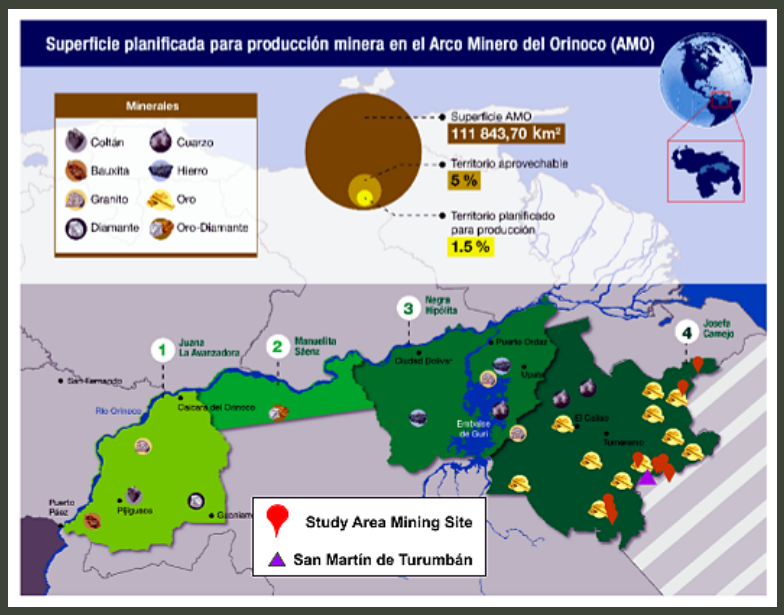


Figure 2: "Oro" translates "gold" in Spanish. Derived from the Department of Ecological Mining Development, Bolivarian Republic of Venezuela. Areas of interest/mining sites are original work. Figure 3: Version of the Mineral Exploration Map of Guyana made by the Guyana Geology and Mines Commission zoomed into the area of study. Areas of interest/mining sites are original work.

POSSIBLE MERCURY TRANSPORTATION ROUTES FROM GUYANA

Air

Figure 4 shows the "Eterimbán" airstrip near the study area from 2007 to 2020. Figure 4a-b shows the airstrip expanding with razed vegetation and light construction to the Cuyuní River. In Figure 4a, there is no indication of the informal settlement of Cañamú. According to InfoAmazonia reporting, "there is no consensus on the founding date of Cañamú" and "what few call Cañamú, has grown between an unpaved airstrip and Etheringbang." According to OpenStreetMap, the airstrip near Etheringbang stands as the sole airstrip on the Guyanese side, opposite the "Aeródromo de Isla de Anacoco" in Venezuela, an airfield located approximately 2 kilometers to the north. In 2021, a news report from Guyana covered an aircraft crash that took place on the Eteringbang airstrip stating "mercury was aboard the aircraft."

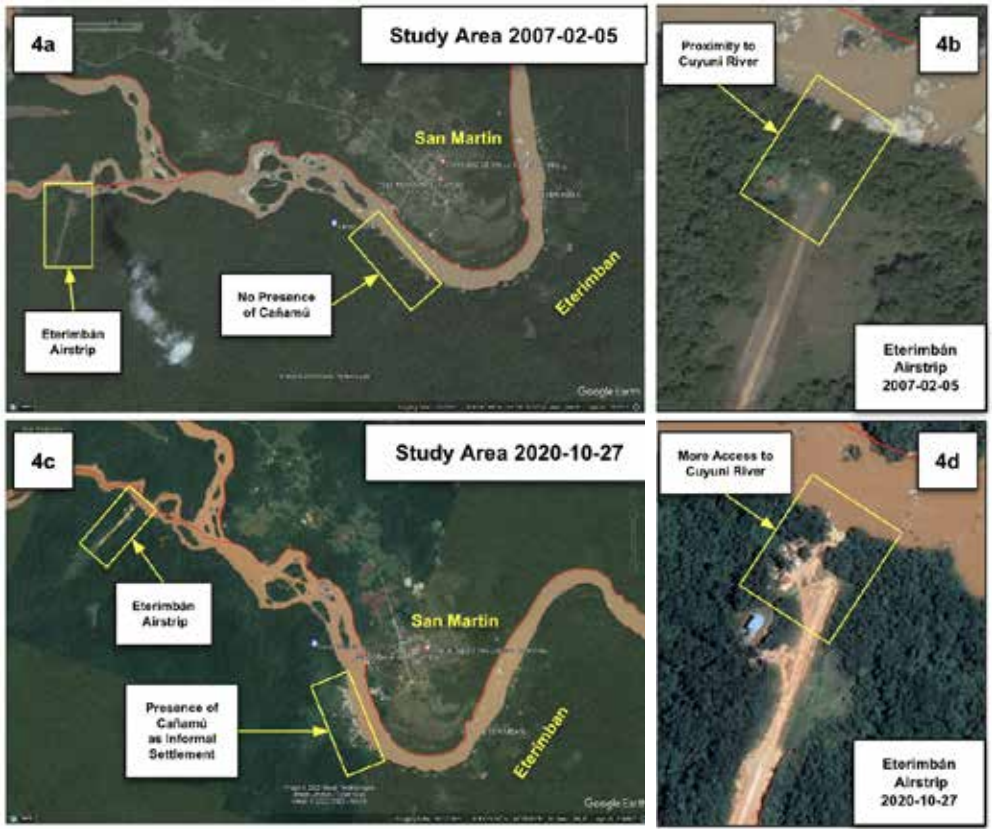
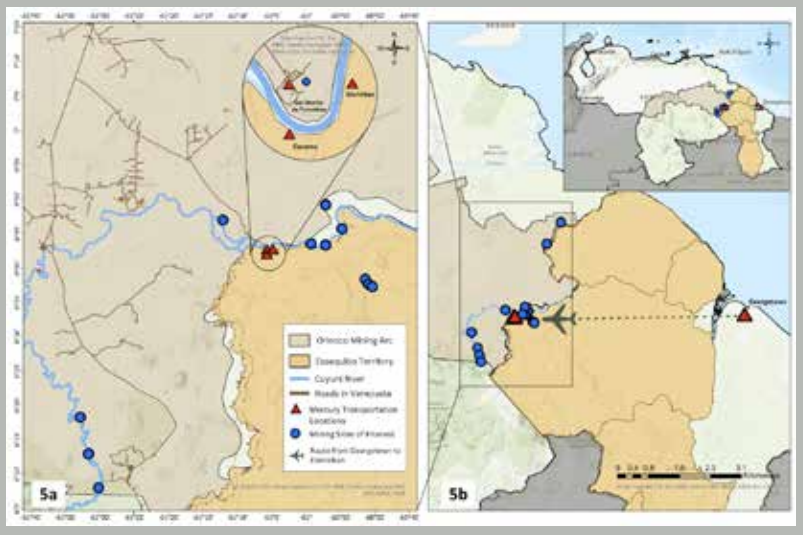


Figure 4:
Locate the Eterimbán airstrip and compare the development of Cañamú and the airstrip's Cuyuní River access between years.
Google Earth, 02/05/2007

River

San Martín de Turumbán and Cañamú Imagery Analysis

Figure 6 shows the regions of San Martín de Turumbán and Cañamú along the Cuyuní River. On the San Martín de Turumbán side, the boat take-off area witnessed significant expansion and the number of structures increased, suggesting a rise in activity over the observed period of 2016 (see Figure 6a) to 2022 (see Figure 6b). Similarly, the Cañamú territory has expanded, with structures suggesting increased activity as well. Moreover, in Figure 6a, a boat appears to be traveling from east to west, specifically from San Martín de Turumbán to Cañamú.



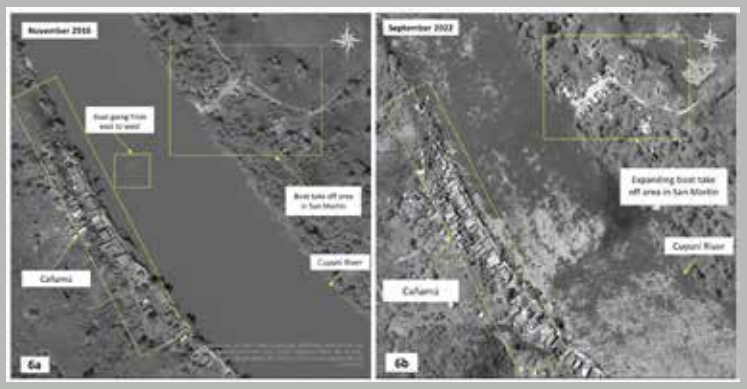


Figure 6: Worldview-1 satellite images sourced from Maxar. Image featuring the boat take-off area with an increase of structures in San Martín de Turumbán, Venezuela, situated across from Cañamú, Guyana, on 11/29/2016 (Figure 6a) and 9/13/2022 (Figure 6b). *(©Maxar 2016 and 2022)*

Figure 5: This map illustrates air routes from Georgetown to Eterimbán and a potential route to other mining sites within the Orinoco Mining Arc. Original work, UMD students. Layers derived from Humanitarian Data Exchange, excluding sites of interest and mercury locations *Google Earth, 10/27/2020*

Roads

The Cuyuni River is a major transport artery, but it is not the only means of passage into the general area under study. Figure 7 notes the road leading into San Martín de Turumbán and also highlights the dense vegetation and remote nature of the Guyana locations under study where mercury can often be sourced on the cheap.

Figure 7: Image showing the road to San Martin and no visible roads amid the thick forest of Guyana locations. *Google Earth, 10/27/2020*

Expansion of Gold Mining in San Martín de Turumbán

Figure 8 represents the progressive expansion of gold mining activities in San Martín de Turumbán from 2017 to 2022. In Figure 8a, there is an initial indication of a gold mining operation above San Martín de Turumbán, featuring a mining pit and a mining tailing pond that have formed. This mining site expanded in Figures 8b and 8c with the addition of new mining pits and tailing ponds. Furthermore, in Figure 8a, there is a forested area on the outskirts of San Martín de Turumbán, directly across from Eterimbán, that has changed drastically over the years. Notable transformations transpired between Figures 8b and 8c as this area evolved into a landscape replete with mining pits and accompanying tailing ponds. Finally, Figure 8a shows a body of water located below San Martín de Turumbán and above the Cuyuní River. This water body underwent variations in coloration as the mining operations along the Cuyuní River escalated, as shown in Figures 8b and 8c.

More recent commercial imagery from April 2023 reveals increased mining clusters along the river banks of San Martín as noted in the 2022 exemplar image in 8c. Additionally, there is an expansion of mining pit areas inland from the shoreline tailing ponds on the San Martín side as of April 2023.

Figure 8: Sentinel 2-Level 1C satellite images. Time-series analysis shows the growth of mining sites above and to the side of San Martín de Turumbán, along the Cuyuní River. *Google Earth*

Comparative Analysis of Other Mining Sites in Venezuela and Guyana to San Martín de Turumbán

Figures 9 and 10 serve as comparison sites to the mining sites within San Martín based on a similar mining expansion and site characteristics over time. Figure 9a is located near the Venezuela- Guyana border on the Venezuelan side. This figure shows small clusters of dry mining pits near the river in 2014, and Figure 9b shows the increase in mining pits in the same area, in addition to tailing ponds, in 2020.

Figure 10a depicts a mining site located near the Venezuela-Guyana border on the Guyana side. This figure shows mining pits with tailing ponds near the river. Figure 10b demonstrates an increase in these mining areas in 2022. In parallel to the mining sites in San Martín de Turumbán, figures 9 and 10 show similar mining expansion over time. Similar mining signatures and proximity to the mines present in San Martín indicate that the mining activity in these nearby sites is probably also artisanal gold mining.

Land Use and Land Cover Change Analysis (LULC) of Gold Mining Sites Along the Venezuela-Guyana Border

We conducted a land use and land cover (LULC) change analysis to quantify the changes in land cover and examine the growth or contraction of mining activity. [2] This automated mining detection was supplemented with literal imagery analysis of all 13 sites to ensure gold mining overhead imagery characteristics were present.

Figure 9:
Images showing the expansion of mining in Mining Site 10 located on the Venezuelan side of the Cuyuni River on 01/03/2014 and 10/17/2020
Copyright Maxar 2014 and 2020

Figure 10:
Images showing mining expansion in Mining Site 6 in Guyana near the Venezuela-Guyana Border from 4/12/2018 to 3/29/2022
Copyright Maxar 2018 and 2022

METHODOLOGY

The image classification utilized the 'Random Trees' algorithm in ArcGIS Pro. The land cover classes were: body of water, forest, mining activity, barren land, and developed. Post-classification processes included manual pixel editing and cloud masking to achieve accuracy assessments of above ninety percent over years of imagery coverage (depending on cloud cover and image availability). Area calculations and change analysis were carried out for the mining activity class to analyze the potential growth or contraction of mining activity at these gold mining sites.

RESULTS

The total number of gold mining sites used for the LULC analysis was 13, with nine sites in Venezuela and four in Guyana. Figures 11 and 12 show the classified imagery generated in the LULC analysis scattered along the border of our study area. The class of interest is the mining activity class, which includes mining pits and mining tailing ponds. If barren land or developed land classes were inside mining activity areas, they were also classified as mining activity to represent the corresponding land use. Furthermore, clouds were masked out, resulting in the white spots in the images. The results in Figures 11 and 12 depict an increase in the mining activity class with a simultaneous decrease in forest over the time frame of 2008 to 2022. This common trend in mining activity expansion was present across all 13 mining sites sampled in the LULC analysis.

Characteristics of Gold Mining

To supplement the automated analysis, we analyzed all 13 sites from overhead imagery for characteristics of suspected gold mining. The general characteristics often include mangled and rough-looking brown or reddish soil scattered with spoon-like holes often filled with water or stand-alone holes and trenches. The water in the craters or ponds often changes color from greenish-blue to brown.

Venezuelan activist and journalist @valendeviaje's Instagram slideshow shows ground, aerial, and overhead photos of gold mining characteristics in Figure 13. She mentions the Cuyuni River in her post, which is part of our study area.

On June 2023, Mining.com reported that a gold mine collapsed from flooding in southern Venezuela, killing 12 miners. The mangled soil and spooned-out crater look are noted in the ground photo (Figure 14).

When ground photos are compared with overhead imagery, the characteristics remain consistent across different imaging platforms, as depicted in Figure 15. Please see the structured data flyovers for each site. The reader's imagery underlays may need to be updated to see all characteristics.

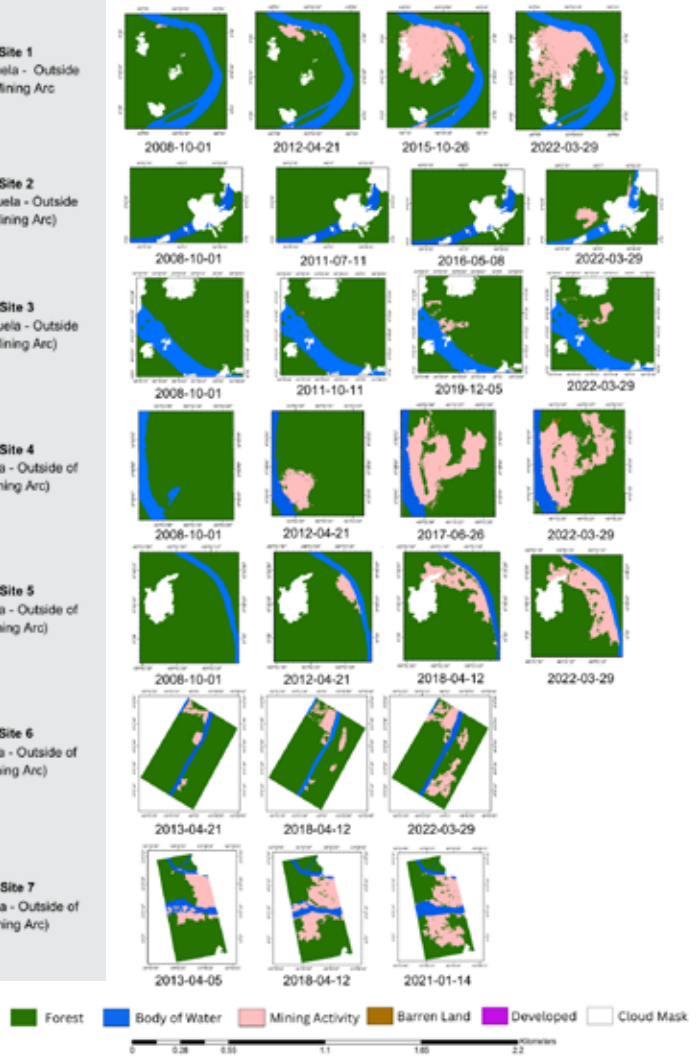


Figure 11:
LULC maps of gold mining sites outside of the mining arc depicting the expansion of mining in pink
(Dervied from Maxar 2008, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2021, and 2022)

Figure 13: Source: @valendeviaje Instagram

Figure 14: Image by MP Americo De Grazia, Twitter.

Figure 12:
LULC maps of gold mining sites inside the mining arc depicting the expansion of mining in pink
(Derived from Maxar 2007, 2008, 2009, 2011, 2012, 2014, 2015, 2016, 2017, 2020, 2021, and 2022)

Figure 15: Image showing spoon-like holes and ponds with brownish water at Mining Site 13
Google Earth Pro, 5/23/2020

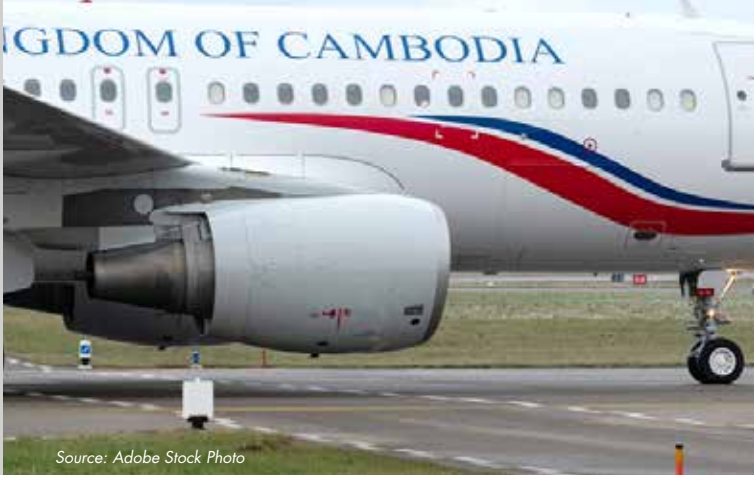
Chinese Investment in Cambodia: The Dara Sakor Airfield

In partnership with Johns Hopkins School of Advanced International Studies and written by Christian Gentile

Due to size limitations, not all Figures were included. The entire article can be found at Tearline.mil

OVERVIEW

The Dara Sakor Airport in Koh Kong, Cambodia is a project under China's Belt and Road Initiative (BRI). The airport contains a 3,300-meter-long runway near the Cambodian coast. Since 2019, Pentagon planners and others in the strategic commentary space have expressed concerns that Dara Sakor could serve as a dual-use Chinese military airfield. As of May 2023, GEOINT shows no military infrastructure is present. Open evidence suggests Dara Sakor may be another overly grand BRI project.**Xian H-6 long-range bomber.** According to Aerospaceweb.org, The H-6 requires 2,100 meters to take off and 1,540 meters to land.



Source: Adobe Stock Photo

Source: © Maxar, April 10, 2023

Source: Google Earth
January 19, 22022

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April 10, 2023

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