Hostile Territory: Lessons Learned from Satellite Imagery of Recent Cross-Border Conflicts
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In 2013, with funding from the United States Institute of Peace, the Geospatial Technologies and Human Rights Project of the American Association for the Advancement of Science began the project “Hostile Territory: Revealing Trends in Cross-Border Conflict Using Satellite Imagery.” The goal of this project was to evaluate the prospects for providing early warning of conflict using analysis of high-resolution satellite imagery of historical border conflicts as case studies. The project analyzed imagery of the belligerents prior to and during the conflict in order to identify the types of observable phenomena that occur prior to the outbreak of violence.

Seven recent conflicts were selected as case studies for this analysis. In order to be selected for analysis, the conflict must have consisted of a dispute primarily between two state actors over the control of territory. In addition, the dispute must have occurred after 2000, as that is when commercial high-resolution satellite imagery became widely available. Furthermore, tensions had to have escalated to the point where some phenomena could be observed with imagery. Therefore, border disputes that were primarily diplomatic in nature were excluded.

Because countries engaged in border disputes almost always differ on the subject of the boundary’s location, and due to the potential for error in the various datasets in use, this investigation did not limit itself to observing phenomena directly adjacent to internationally-recognized frontiers. Instead, the entirety of the disputed area was considered for analysis, along with, in many cases, facilities such as military bases that were located deep within uncontested territory, but which were deemed relevant to the conflict.

Case studies were selected in pairs based on geographic proximity and history in order to determine if any trends could be identified based on the region and historical causes of the conflict. The categories the case studies were selected from included disputes stemming from the end of African colonialism, the end of colonialism in South and Southeast Asia, and the fall of the Soviet Union. To study disputes stemming from the end of African colonialism, the 2011-2012 war between Sudan and South Sudan and the 2008 conflict between Eritrea and Djibouti were selected. The 2002 standoff between India and Pakistan, and the dispute between Cambodia and Thailand over the Preah Vihear
Temple were studied to analyze disputes resulting from the end of colonialism in South and Southeast Asia. Originally, two disputes between former soviet states were selected. These were the 2008 war between Georgia and Russia, and the continuous dispute between Armenia and Azerbaijain. The seventh case study was added when, in spring 2014, the Euromaidan protests in Ukraine sparked the crisis between Ukraine and Russia.

The reports of the results of this project are grouped into sections based on these three regions. Each section includes the results of each case study and an intra regional comparison of the regional case studies. The results of each case study begin with an overview of the conflict followed by a discussion of the motivations of the actors and the internal significance of the conflict to them. A summary of the manifestations of the conflict that were observed through satellite imagery analysis is then presented. The key findings, as they relate to early warning, are then discussed.

The intra-regional comparison can be found at the end of each section. Here, similarities and differences between the case studies are discussed in order to determine what, if any, trends can be identified. The report ends with an inter-regional comparison to identify what trends can be identified by comparing the border disputes in different regions.
Introduction
On 9 January 2005 the Sudan People’s Liberation Movement (SPLM) and the Government of Sudan signed a series of agreements known as both the Comprehensive Peace Agreement (CPA) and the Naivasha Agreement, the aim of which was to bring an end to the second Sudanese civil war. Among other features, the CPA stipulated that South Sudan would hold a referendum between 9 and 15 January 2011 to decide the matter of independence. The CPA also afforded the oil rich Abyei Administrative Area (AAA) a unique administrative status, assigning, until the referendum, governing responsibilities to a locally elected Executive Council. The 2011 referendum would then have given Abyei residents a choice between joining Sudan, joining South Sudan, or remaining a special administrative area. However, in the months leading up to the referendum, Sudan and South Sudan could not resolve the issue of voter eligibility for nomadic Misseriya tribes who spend part of each year in Abyei. As a result, the referendum was not held in Abyei.  

The referendum went ahead in the rest of South Sudan resulting in South Sudan voting to form an independent state. Immediately following the referendum, violence erupted in several locations throughout Sudan and South Sudan. Fighting occurred in the AAA, the Nuba Mountain Region, Darfur, Blue Nile, and the Heglig region. These conflicts involved multiple parties, including both government and non-state actors. This study, however, focused exclusively on the conflicts in Abyei and Heglig as they were the areas where control of territory was disputed between Sudan and South Sudan.

To analyze the conflict, imagery was acquired of 14 sites (Figure 1) in Sudan and South Sudan. These sites included towns, forward military positions, and rear area military bases. Three of the sites were large, permanent, Sudanese military bases located at least 75km from the border with South Sudan. Five towns situated on or near the border were also selected along with six forward military positions. In total, 50 images from 2010-2012 were acquired for analysis.

It should also be noted that multiple sites in the Abyei area were not covered by this study to avoid duplicating the work done by the Harvard Humanitarian Initiative. In their assessment of the Abyei conflict, new militia camps were observed prior to the conflict near three towns north and west of the Abyei Administrative Area; Sitaib, Debab, and Meiram. In addition, the Harvard Humanitarian Initiative observed increases in the number of troops present at the SAF base at Nyama and the SAF airbase at Muglad (Figure 1). These observations were strong indicators of imminent violence in Abyei.

Motivations and Significance
The causes of the 2011-2012 war between Sudan and South Sudan date back, in part, to the decades long civil war that ended with the Comprehensive Peace Agreement of 2005 and led to the creation of South Sudan in 2011. The causes of the civil war included disputes over oil rights, ethnic conflicts, and migration rights of nomadic groups. In early 2011, these issues were present in Abyei during the months preceding the planned Abyei Independence Referendum.
FIGURE 1: Selected sites in Sudan and South Sudan
**FIGURE 2: Two temporary camps in Jau.** Between 30 September 2010 (A) and 15 January 2011 (B), two camps of tightly packed structures or tents (red boxes), arranged in rows, were constructed near Jau. By 16 December 2011 (C), these structures had been removed with no signs of fighting or fire. Images DigitalGlobe | Analysis AAAS. Coordinates 10.2785 N, 29.9971 E.

**FIGURE 3: Improvements to the Talodi Airfield.** Between 2 February 2011 (A) and 4 January 2012 (B), the runway was extended and straightened (red arrow), an earthworks barrier was constructed around it (blue arrow), and a nearby compound was cleared (orange arrow). By 18 December 2012, the runway was paved (red arrow), a second, smaller runway and apron were constructed (yellow arrow), support structures were added to the nearby compound (orange arrow), and a military compound was added (green box). Images DigitalGlobe | Analysis AAAS. Coordinates 10.6231 N, 30.3970 E.

**FIGURE 4: Dam constructed west of Talodi.** A dam was constructed between 4 January 2012 (A) and 18 December 2012 (B). Images DigitalGlobe | Analysis AAAS. Coordinates 10.6381 N, 30.3693 E.
In 2004, while the Comprehensive Peace Agreement was being negotiated, Abyei accounted for 25% of Sudan’s oil production. This estimate included oil fields in the nearby Heglig area, an area which was later deemed to be outside of the Abyei Administrative Area. In 2009, the declining productivity of the Abyei oil fields and the decision to place the Heglig oil fields outside the AAA meant that Abyei only accounted for 1% of Sudan’s annual oil production. Despite the decline in oil production, oil can still be considered a factor in the conflict, as ownership of the oil fields was a key consideration in the creation of Abyei as a special administrative area.

Oil was also a factor in Heglig where the 2012 conflict was precipitated in part by the failure of Sudan and South Sudan to reach an agreement on fees for transporting South Sudanese oil through Sudan to global markets. In this case, the conflict itself involved the taking of the town of Heglig, which holds key oil facilities. In addition, much of the Sudanese civil war was over control of oil fields. As the 2011-2012 conflicts can be considered an extension of the Sudanese Civil War, control of oil production should be treated as a root cause of the conflict.

Ethnic tensions and migratory rights were also factors in the Abyei conflict. The Abyei region is primarily inhabited by two ethnic groups, migratory Misseriya and the Dinka Ngok, who reside in Abyei year round. Between September and January, the Misseriya migrate from their wet season grazing grounds northwest of Abyei through Abyei to southern grazing areas for the dry season. In the past, the government in Khartoum has armed Misseriya militias, leading to clashes with the Dinka Ngok. This history of violent clashes contributed to Sudan and South Sudan’s inability to reach an agreement on Misseriya eligibility for participation in the Abyei Independence Referendum.

The war between Sudan and South Sudan can be considered an extension of the decades long Sudanese civil war. The ethnic tensions and conflicts over migration rights that gave rise to much of the civil war’s violence have remained following South Sudanese independence. In addition, the ownership and control of oil producing regions, as well as the use of oil infrastructure, played a major role in both the Sudanese civil war and the 2011-2012 war.

**Manifestations**

The war between Sudan and South Sudan involved large amounts of military equipment and troops deployed over a large area. As a result, a number of phenomena were observed prior to, and during, the conflict. These included new military installations, the construction of infrastructure, destroyed civilian structures, and movement of materials to and from military bases.

New military installations were observed in multiple locations. During the conflict, three camps were constructed near Talodi, consisting of regularly arrayed tents and structures surrounded by earthworks. At one camp, artillery and revetments were observed. In Jau, two tightly packed rows of tents were observed prior to the start of the conflict (Figure 2). These tents were arranged in an orderly manner indicative of a military encampment. In addition, several military camps were constructed or expanded in the area around Heglig.

The construction of new infrastructure was also observed. The airport at Talodi was improved from a small dirt landing strip to a paved 1,800m long runway (Figure 3). In addition, a new dam was constructed west of the town, 3km from the newly expanded airport (Figure 4). These two projects represent a major investment in the infrastructure around a strategically important town.
FIGURE 5: Military helicopters and damage in the central depot. Between 16 February 2011 (A) and 27 May 2011 (B), the Mil Mi-24 helicopters were removed while a Mil Mi-8 helicopter was added. Structures across the road from the central depot were destroyed by fire (yellow box) while structures within the depot were undamaged. Images DigitalGlobe | Analysis AAAS. Coordinates 9.5860 N, 28.4496 E.

FIGURE 6: El Obeid Materials Depot. On 22 October 2010 (A), the depot is filled with materiel and surrounded by multiple bunkers, revetments, and guard posts (red dots). On 19 January 2011 (B), the area remains largely unchanged. By 13 November 2011 (C), much of the materiel has been removed, as have three defensive positions (blue dots). By 7 December 2012 (D), almost all of the structures and materials have been removed and only six of the original 24 defensive positions remain. Images DigitalGlobe | Analysis AAAS. Coordinates 13.1586 N, 30.2279 E.
At two of the towns for which imagery was acquired, Heglig and Abyei, multiple civilian structures were destroyed over the course of the conflict. In both locations, large numbers of small, residential structures had been burned. At the same time, most of the larger, industrial, structures remained relatively unscathed. In Abyei, a large compound in the center of the town, where military helicopters were observed, was undamaged despite the destruction of structures directly across the street (Figure 5). In Heglig, there was some damage to a small number of industrial facilities, but the vast majority of these facilities were untouched.

The movement of materials to and from military bases was also observed. At the El Obeid Airbase, a drastic reduction in materials was observed during the conflict. (Figure 6). On 22 October 2010, the base is filled with shipping containers and multiple large, hanger like structures. By 13 November 2011, most of the shipping containers had been removed and by 7 December 2012, only one of the hangar structures remained. During this time period, new trucks and other materials were observed at the Kadugli Army base. Though satellite imagery analysis cannot determine if the materials removed from El Obeid are the same as those that appeared in at Kadugli, these observations imply that materials were being moved from rear bases towards the front before and during the conflict.

Summary of Findings

Imagery of fourteen sites in Sudan and South Sudan were selected and analyzed in order to identify signs indicating that an escalation of border tensions was likely. Three sites were military bases positioned over 75km from the border. Eleven sites near the border in the contested regions of Abyei and Heglig were also selected. These included five border towns and six forward military positions.

The three rear military sites were chosen to monitor the movement of materiel to the front lines. The images of these sites covered a time period from before the South Sudan Independence referendum until after the conflict in Heglig had subsided. The time between image pairs at the same location ranged from a minimum of 2.5 months to a maximum of 11 months.

The low temporal resolution provided by these images proved to be the greatest challenge for analysis. At all three locations, changes in the numbers and positions of troops and equipment were observed. However, it was difficult to determine the significance of these changes due to the imprecise timetable caused by the low temporal resolution. For example, the number and types of aircraft present at the Kadugli Airbase included seven Mi Mil-8 helicopters, one Antonov, and one Mi-26 heavy transport helicopter. None of the images contained all of these aircraft at the same time, and in one image no aircraft were present. It is unclear whether these differences represented actual changes in the deployment of aircraft in Sudan during the conflict or if they merely reflected which aircraft were not actively engaged in operations at the time of image acquisition.
At El Obeid, the movement of materiel from the central depot was one key observation of the project. Between 19 January 2011 and 13 November 2011, the Sudanese Armed Forces (SAF) began moving large numbers of shipping containers out of the depot, presumably to support military activities. Drawing conclusions from the analysis of rear military bases, particularly the Kadugli Air and Army Bases, was complicated by the conflict in the Nuba Mountains that occurred in the months between the Abyei and Heglig conflicts. This conflict was not specifically targeted for study as it was deemed to be primarily an intrastate conflict. Given the complex and interconnected history of the South Sudanese independence movement and the shifting alliances of the ethnic militia groups it involved, it is impossible to completely separate fighting in one area of the region from fighting in others. It is, therefore, possible that some materiel that was moved from these sites was destined for the Nuba Mountains rather than Heglig or Abyei.

Three sites in the Abyei area were selected to assess the conflict that occurred within the AAA. Imagery of these sites was captured between December 2010 and November 2011 and the time between two images of the same site ranged from less than one month to almost 11 months. Analysis of one site, the town of Agok, revealed surprisingly little activity throughout the conflict. The town lies on the border between Sudan and South Sudan but no troops were observed in any of the three images acquired.

In the town of Abyei, the most significant observation in the images preceding the conflict was the addition of over 750 new structures. These primarily appeared to be small white tents scattered around the outskirts of town. The addition of such a large number of temporary, randomly placed, structures suggests the movement of a large number of civilians into the town. The imagery did capture substantial military activity in Abyei during the conflict. This included tanks, artillery, helicopters, and the destruction of civilian structures. Despite this destruction, imagery from 27 May 2011 showed that the central depot in Abyei was largely undamaged. Structures nearby were clearly burned but the depot was untouched. This suggests that the SAF may have avoided targeting the compound. A similar lack of destruction of large compounds was observed in Heglig.

Eight sites in Heglig were selected to assess the conflict that occurred within the region. The time between image pairs of the same site ranged from 1.5 to eleven. Analysis of three sites outside of the Heglig area revealed some signs of impending violence. In Jau, the addition of 260 structures between 30 September 2010 and 15 January 2011 appears to have been due to a military build up. Though there were no conclusive observations, such as artillery or tanks, to confirm that the camps were military, the layout of the structures was much more orderly than the temporary camps observed throughout the region. However, the fact that the tent camps had been removed and multiple structures in Jau were destroyed by 16 December 2011, prior to the start of the Heglig conflict, suggests that these troops may not have been engaged in Heglig. More frequent imagery would have provided more detailed information on the precise timing of the camp’s removal and the damage to Jau, which could indicate the theater to which the troops were deployed.

Over the course of the conflict, dramatic changes were observed at Talodi. The exact order of these changes is difficult to determine as the three images used for analysis were captured with 11-month
gaps between each. Despite the low temporal resolution, certain observations can be made. The airport was dramatically expanded between 2 February 2011 and 18 December 2012. On 4 January 2012, the expansion appears to have recently begun as the runway was expanded but it had not been paved. The 18 December 2012 image, however, shows the paved runway and a second runway and apron. Therefore, much of the expansion occurred after the conflict in the Nuba Mountains had subsided. Similarly, two military bases on the southern and eastern outskirts of Talodi were also significantly expanded in this period. Such expansion, in addition to the construction of a dam, suggests that the Government of Sudan viewed the town of Talodi as strategically important and added troops and infrastructure to strengthen it. This could have been done in anticipation of the Heglig conflict, but it may also have represented an attempt to assert territorial control over the region following the conflict in the Nuba Mountains.

Analysis of the five sites in the Heglig area revealed few signs of impending violence but many signs of increased military activity following the conflict. In the two Teshwin sites, for instance, no buildup of troops was observed prior to the outbreak of violence. The imagery taken after the conflict, however, showed a major expansion in the SAF base at Teshwin West, roadblocks near the base, and lines of foxholes to the south as well as lines of foxholes near major infrastructure in Teshwin East. This suggests that early fighting occurred between troops already stationed near the border. It was only after the conflict that the SAF bases in Heglig were substantially expanded. Finally, the additional infrastructure and military equipment at Talodi demonstrates that the Government of Sudan considers the town to be of strategic importance. Identifying other infrastructure projects could help determine which towns the regime considers to be of high value. These towns could then be targeted for monitoring.

**Conflict Resolution**

By May 2012, Sudan People’s Liberation Army (SPLA) forces had withdrawn from the Heglig area. The dispute over oil rights and border demarcation was then referred to African Union mediated talks in Addis Ababa. These talks had begun several months prior to the South Sudanese Independence Referendum and were ongoing at the start of the conflict. On 27 September 2013, Sudan and South Sudan signed multiple agreements on issues including oil rights and the creation of demilitarized buffer zones. However, the two sides were unable to reach an agreement on the status of Abyei, leaving that aspect of the conflict unresolved.

**Early Warning Signs**

In the Sudan-South Sudan border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the movement of materiel to and from various military installations, such as El Obeid and Kadugli.
- the construction of military installations, such as occurred at Kadugli and Jau; and
- the construction of infrastructure, such as the improvement of the runway at Talodi.
Djibouti and Eritrea: 2008

Introduction

The origin of the 2008 border conflict between Eritrea and Djibouti has its roots in the colonial era. A 1900 protocol defined the boundary between French Somaliland and the Italian colony of Eritrea as running from the farthest tip of Cape Doumeira on the Red Sea, westward along the watershed of the Ras Doumeira peninsula for one kilometer, and then following a straight line to a point marked on a contemporary map. This protocol had the effect of dividing the peninsula into a northern Italian (later Eritrean) zone and a southern French (later Djiboutian) zone. The status of Doumeira Island, located just off the tip of the cape, was left unresolved by the convention; both powers agreed to determine its status later, and subsequently neglected to do so.

The basis for Eritrea’s claim to the area of Ras Doumeira derives from the signing of a 1937 treaty in which France agreed to cede the territory to Italy, along with the aforementioned island – an action which Eritrea views as carrying the force of law. Djibouti, on the other hand, points to the failure of the French National Assembly to ratify the treaty as rendering the treaty null and void. Such matters remained largely of academic interest until 1993 when Eritrea, having gained her independence following a protracted war with Ethiopia, re-asserted her claim to Ras Doumeira. The situation nearly became violent in 1996, when Djibouti accused Eritrea of shelling and then sending troops into territory it considered its own.

Motivations and Significance

According to statements presented by Djibouti at the United Nations, the most recent conflict began on 4 February 2008 when regional authorities in northern Djibouti noticed construction activity on the Eritrean side of the border – ostensibly for the purposes of building a road linking the two countries. Six days later, Eritrean construction equipment is alleged to have been taken across the border without permission and, instead of being used to build a road, was used to begin erecting fortifications at Ras Doumeira. Soldiers of the Eritrean Defense Forces (EDF) then occupied Ras Doumeira beginning in mid-March. Military activity at the site was allegedly confirmed by Djibouti on 7 April, when EDF personnel turned back a Djiboutian government delegation sent to investigate the activity on the peninsula. Eritrea contested Djibouti’s version of events, but largely refrained from commenting on the situation, other than by issuing blanket denials that its troops were impinging upon foreign territory. The Eritrean government refused to allow the United Nations fact-finding mission to investigate conditions on the ground; as a result, only Djibouti’s account was provided to the Security Council.
FIGURE 7: Overview of Djibouti, Eritrea, and Ras Doumeira
FIGURE 8: Ras Doumeira and environs on 10 December 2007. On 10 December 2007, all formal roads stop on the outskirts of a small village in undisputed Eritrean territory (inset top). Ras Doumeira (inset bottom) is unoccupied. Images Digital Globe | Analysis AAAS. Coordinates: 12.69 N, 43.12 E.

FIGURE 9: New road, sand pits, and excavation equipment. New construction has taken place along the border between December 2007 and April 2008. Image Digital Globe | Analysis AAAS. Coordinates: 12.727 N, 43.098 E.
On 17 April 2008, as diplomatic negotiations between the two countries at the United Nations continued, the Djibouti Armed Forces (DAF) deployed to the slopes of Ras Doumeira, often mere meters from their Eritrean counterparts. Between that date and mid-June, several dozen Eritrean soldiers then defected by crossing the border into Djibouti, whose armed forces refused EDF requests for their repatriation. According to Djibouti, events came to a head on 10 June, several hours after DAF personnel ignored an EDF ultimatum to return an officer who had defected earlier that day. Hostilities allegedly erupted at 18:40 local time and lasted for more than 24 hours, with the loss of 40-60 DAF troops and an unknown number of EDF casualties. Following these clashes, on 12 June the DAF is reported to have withdrawn to positions several kilometers from Ras Doumeira while EDF forces remained in their positions.

The standoff at Ras Doumeira had potential implications that extended far beyond Eritrea and Djibouti. The easternmost border between the two countries occupies an arid, remote, yet strategic position overlooking the straits of Bab-el Mandeb, at the southern entrance to the Red Sea. Over ten thousand ships pass through the straits each year, carrying tens of billions of dollars worth of cargo, including four percent of the world’s oil supply. Due to its proximity to one of the most important shipping routes between Europe and Asia, a renewed conflict in the region could have a significant destabilizing effect on the global economy, particularly if it were to result in the deployment of sea mines or naval forces. A thorough understanding of the dispute is important, therefore, in order to mitigate the risk of future armed conflict.

**Manifestations**

Analysis of the border region focused on five categories of observations. The first of these was the deployment of weapons systems, such as artillery and mortar emplacements. The second category consisted of vehicles, many of which were observed changing places throughout the study period. The third category involved the number of fortifications such as earthworks, entrenchments, and other barriers designed to control access or provide cover. The fourth category consisted of buildings and structures, while the fifth category involved the results of weapons use. The absence of color information in the imagery presented a challenge to image analysis and interpretation; in panchromatic (black and white) images, it can be difficult to distinguish fighting vehicles from those carrying supplies or otherwise supporting the deployed forces. Because of this ambiguity, all vehicles were counted within a single category regardless of their suspected role, while “weapons systems” refers solely to armaments located in fixed positions.

On 10 December 2007, imagery depicts the demilitarized state of affairs that existed prior to the escalations reported two months later. Ras Doumeira and Doumeira Island show no signs of occupation, nor are there any formal roads leading beyond a small village located at coordinates 12.729N, 43.086E on the Eritrean side of the border (Figure 8). The most prominent sign of vehicular traffic near the border itself takes the form of numerous tire tracks that crisscross the area, and whose directionality varies widely. A small informal path appears to have been worn through the desert by occasional cross-border vehicle traffic, however no infrastructure can be seen demarcating the border itself. On the outskirts of the same Eritrean village where the road ends, heavy equipment
FIGURE 10: New structures, fortifications, and vehicles on the northern slopes of Ras Doumeira. On 27 April 2008, the northern slopes of Ras Doumeira show extensive activity. Image Digital Globe | Analysis AAAS. Coordinates: 12.710 N, 43.131 E.

FIGURE 11: New fortifications. Nineteen new fortifications were observed several kilometers south of Ras Doumeira on 27 April 2008. Image Digital Globe | Analysis AAAS. Coordinates: 12.656 N, 43.144 E.

FIGURE 12: Emplacement of probable mortar positions on the Eritrean side of Ras Doumeira. On 27 April 2008 (top), Ras Doumeira is occupied, but no weapons are apparent. By 30 June, however, four new mortar emplace-ments (arrows) had been added. Images Digital Globe | Analysis AAAS. Coordinates: 12.712 N, 43.133 E.

FIGURE 13: Craters observed in the desert. On 30 June 2008, new craters (indicated by arrows) were observed in the desert between the opposing forces. Nearby tire tracks may suggest that vehicles were being targeted. Image Digital Globe | Analysis AAAS. Coordinates: 12.678 N, 43.127 E.
was observed excavating a large pit in the desert sand (Figure 9), consistent with reports that the Eritreans were engaged in road construction prior to the outbreak of hostilities.

By 27 April, the situation had changed drastically. A roadway had been constructed connecting Ras Doumeira with the Eritrean road network via the village located at 12.729N, 43.086E. Further inland, a second new roadway, 11 kilometers long, had extended southward into Djibouti (Figure 9). Additional sand pits and excavating equipment were observed supporting this new construction. At Ras Doumeira itself, extensive activity was visible. On the northern slopes of the peninsula, numerous new structures had been erected, extensive fortifications and entrenchments were constructed, and a number of patrol-type boats could be seen anchored in a cove offshore (Figure 10). Doumeira Island had also been occupied, with new construction visible on the west side of the landmass, and a patrol-type boat present in a small inlet nearby. On the southern slopes, several dozen motor vehicles were apparent, along with several tent-like structures, and earthmoving equipment that appears to be in the process of constructing additional fortifications. Several kilometers further south along the coast, a number of defensive positions appear to have been erected in uncontested Djibouti, accompanied by a comparable number of vehicles, with additional fortifications under construction using earthmoving equipment (Figure 11). In total, 74 Structures, 99 Vehicles, and 33 fortifications were observed in this image.

By 30 June, the situation had evolved further. The fortifications on the southern slope of the peninsula that were under construction in April were complete, but the associated tents and vehicles were no longer present, suggesting that the fortifications may have been abandoned between April and June. Simultaneously, the line of fortifications located south of the peninsula in Djibouti had expanded substantially, and an additional set was constructed even further to the south. On the northern slope of Ras Doumeira, the circular outlines of new mortar emplacements had appeared in several locations, and activity appeared to be continuing at a level similar to that which was observed in April, with several new structures completed during the intervening months (Figure 12). Finally, 20 craters from artillery fire had appeared in the desert to the southwest of Ras Doumeira (Figure 13). Many of these were located in close proximity to fresh tracks in the sand, which may suggest that vehicles were the intended targets of the barrage. Due to the lack of additional evidence, however, this cannot be confirmed.

Imagery from 13 July suggested that the situation had largely stabilized along the lines observed in June, with only a small number of additional fortifications constructed well to the south of the contested area. No additional craters or other signs of fighting were observed in the study area, suggesting that the episode of hostile action between the opposing forces was relatively brief. Although the armies of both belligerents remained deployed in the area, the bulk of their forces appeared to be separated from one another by several kilometers, potentially reducing the likelihood of inadvertent escalation.
Summary of Findings

The results of this analysis are consistent with reports of a buildup of opposing forces on the peninsula of Ras Doumeira, culminating in a skirmish that took place between April and June of 2008. This appears to have been followed by a partial withdrawal and subsequent standoff during which the forces faced each other from fortified positions over a distance of several kilometers. The presence of excavation equipment and sand pits near the small Eritrean village located at 12.729N, 43.086E (Figure 9) is consistent with reports that that country was engaged in road construction during the period preceding the standoff. The apparent availability of such a quarry in undisputed Eritrean territory, however, does call into question the necessity of crossing into Djibouti to obtain construction material, as Eritrea allegedly claimed.

It is unclear whether the vehicles observed next to an earthwork near the border in December 2007 were related to the events that took place in the following months; however, their association with an apparent fortification suggests the possibility of such a connection. If the two are related, this may indicate that preparations for the fortification of Ras Doumeira began several months in advance.

The militarization of the northern half of Ras Doumeira appears to have been well-established by 27 April 2008, consistent with Djibouti’s claim that Eritrea occupied that area beginning around 10 April. The fortification of the southern half of the peninsula, by contrast, appears substantially less advanced on that same date, with numerous construction and logistics vehicles present – some of which can be seen actively constructing new earthworks in the area. These observations reinforce Djibouti’s claim that the DAF deployment on the southern half of the peninsula took place in response to the EDF’s presence on Ras Doumeira’s northern half.

In addition to its forward-deployed assets at Ras Doumeira, Djibouti appears to have maintained substantial forces in reserve, occupying a number of fortifications several kilometers south of the peninsula. These appear to have been first constructed contemporaneously with the initial DAF deployment to Ras Doumeira. However, the scale of the activity behind the front lines increased substantially between April and June – a period which coincides with Djibouti’s reported withdrawal from the southern half of the peninsula. It is plausible that the vehicles (and, presumably, the troops accompanying them), which bolstered Djibouti’s rear-echelon defenses during this period, arrived from the abandoned fortifications at Ras Doumeira. The increase in vehicle tracks located in the desert to the southwest of the peninsula over the study period also suggests that one or both forces may have undertaken vehicular patrols in the no-man’s land that separated the two forces. If the craters observed nearby formed simultaneously, it is possible that these patrols may have represented a tempting target for the artillery of the opposing side.
The brief conflict between Eritrea and Djibouti demonstrated the need for a clear delineation of the border between the two countries. In the absence of an unambiguous boundary, the Eritrean deployment of troops to Ras Doumeira, which that country’s government may have interpreted merely as an assertion of sovereignty, was perceived by Djibouti as an incursion into its territory worthy of a military response. As the standoff continued, the goals of both sides appear to have evolved; the outbreak of hostilities was not tied directly to the occupation of territory by either side, but to Eritrea’s demand for the return of the soldiers who had defected to Djibouti.

The evidence that can be deduced from the available imagery is largely consistent with the timeline that Djibouti submitted to the United Nations in its complaint against Eritrea. In imagery collected several months prior to the confrontation, there was little that would indicate an imminent threat to cross-border stability, although in light of subsequent events, several elements suggest that the Eritrean deployment may have been planned ahead of time. One lesson that can be drawn from this analysis is the importance of logistics when border conflicts take place in remote areas. Adequate road infrastructure appears to have been an important prerequisite to the militarization of the border at Ras Doumeira, and earthmoving equipment was observed near the site several months prior to any military deployment. Although bulldozers alone cannot be considered a definite indicator of imminent border conflict—the number of innocuous uses of such machinery is nearly infinite—the deployment of construction equipment in or near a disputed border may be one sign that suggests the potential for future escalation in remote border areas.

Conflict Resolution

Following Djibouti’s withdrawal from the area surrounding Ras Doumeira, Eritrean forces remained in place. In 2010, however, they also withdrew from the peninsula to make room for a force of 700 Qatari peacekeepers, who occupied the disputed territory while diplomats from both sides negotiated a permanent settlement of the issue at talks in Doha. A final agreement between the parties was signed on 6 June 2010.17,18

Early Warning Signs

In the Eritrea-Djibouti border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the construction of new roads leading to the border;
- the small scale movement of logistics material; and
- the deployment of troops to the border.
In an area as large and diverse as Africa, it is perhaps not surprising that there is no “one size fits all” template by which border conflicts take place. Indeed, at first glance, the Sudan/South Sudan and Djibouti/Eritrea conflicts appear to have little in common with respect to their origins, geographic extent, and intensity of violence. In Sudan, fighting occurred in multiple states over an area of hundreds of square kilometers and involved thousands of soldiers. Along the disputed border between Eritrea and Djibouti, by contrast, the majority of hostilities took place along a front just one kilometer long. A number of factors may have contributed to this disparity, including the perceived strategic importance of Ras Doumeira, the harsh desert terrain inland of the peninsula, and the material resources available to the belligerents. Eritrea, the wealthiest of the combatants in the Doumeira conflict, has a GDP estimated to be approximately 40% the size of South Sudan’s, and neither it nor Djibouti possess significant petroleum reserves. The smaller populations of Eritrea and Djibouti may also contribute to the decreased scale of the conflict in the Horn of Africa; combined, these nations represent just 62% of the population of South Sudan alone. In addition, the decades-long civil war between Sudan and South Sudan ensured that there were a number of well-armed groups already in the area at the outbreak of violence.

These differences in scale were associated with a similar disparity in the intensity of the conflict. The conflict between the Sudan and South Sudan was characterized by widespread violence and destruction. Heavy weapons, including tanks, artillery, and aircraft were deployed over a large area. This resulted in the destruction of multiple villages in Abyei and the displacement of nearly 110,000 Dinka Ngok. In addition, the destruction of both civilian structures and military installations were observed in Heglig. The exact number of military casualties from the conflict is difficult to estimate, but Sudan claimed that over 1,000 troops were killed in Heglig alone. In contrast, the Eritrea/Djibouti conflict did not displace any civilians and resulted in far fewer casualties. The number of casualties in the dispute over Ras Doumeira is not known precisely, due to Eritrea’s refusal to acknowledge the existence of the skirmish. If their losses were comparable to those reported by Djibouti, however, the total would range from 80 to 120 combat deaths.

The two conflicts also differ with respect to the origin of the dispute. In the Horn of Africa, the primary motivation of the belligerents stemmed from a desire to assert or defend national sovereignty over territory whose boundaries had been poorly defined since the colonial era. Although colonial borders also played a role in shaping the conflict between Sudan and South Sudan, they were not its proximate cause. Rather, the incorporation within a single state of the predominantly Muslim, Arabic-speaking

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**Sudan and South Sudan 2011–2012**

**Djibouti and Eritrea 2008**
northern population and the Christian/animist population of the country’s south was the ultimate cause of the civil war that led to the independence of South Sudan. Due to the presence of oil resources, the Comprehensive Peace Agreement, which ended the Sudanese civil war, provided Abyei with a special administrative status. Though the status of Abyei was to have been decided at the same time as the South Sudanese Independence Referendum, the failure to reach an agreement over which groups were eligible to vote in the Abyei referendum prevented the vote from occurring; this was a major cause of violence in Abyei. Thus, though the dispute over Abyei was originally centered around oil resources, by 2011, ethnic disputes involving migratory and residency rights were the main drivers of the conflict. Recent events in what some are calling the South Sudanese civil war imply that the Heglig crisis may also have been a reflection of a power struggle between different South Sudanese factions.

Despite these differences, a number of similarities were observed in imagery analysis of both confrontations. Foremost among these was the importance of infrastructure. Three of the four parties to the two conflicts fall within the lowest tier of the United Nations’ Human Development Index (the fourth, South Sudan, is not ranked at all, due to insufficient data). In these countries, the transportation sector is often rudimentary, and infrastructure outside of major cities is practically nonexistent. As a result, in many cases simply transporting soldiers and materiel to the border in significant quantities represents a substantial logistical challenge. This is particularly true when the area under dispute is located in a remote or otherwise inaccessible location. In such cases, an early sign of the impending conflict appears to be the construction of transportation infrastructure, particularly roads. The usefulness of roads as an indicator is enhanced by the fact that in most cases it is governments, rather than individuals or corporations that are responsible for their construction — particularly in remote areas. The presence of a new road toward a border, therefore, suggests a degree of governmental interest in the frontier. In Eritrea, this interest was visible in satellite imagery through the presence of earthmoving equipment and a partially completed road toward Ras Doumeira, which were the first indications that the area held any significance. In Sudan and South Sudan, infrastructure improvements were also observed, in the form of airport expansion and the construction of a dam at Talodi. These infrastructure improvements occurred during the conflict, implying that Talodi was determined to be a key strategic location. In isolation, these developments are not sufficient to cause alarm; cross-border roads have myriad purposes, including trade, tourism, and migration. If geopolitical tensions already exist, however, such developments may warrant additional scrutiny, particularly in regions like Africa, where such development is less common and relatively expensive.
Introduction

The temple complex of Preah Vihear is situated on the southern edge of the Khorat Plateau, in the Dangrek Mountains, near the border between Cambodia and Thailand (Figure 13). A hermitage was founded on the site during the 9th century, and the complex was expanded over the course of the Khmer Empire. By the 11th century, it included a series of sanctuaries linked by paved paths and staircases.

In 2001, Cambodia began the process of having the temple inscribed as a UNESCO World Heritage Site. In the subsequent years, the inscription of Preah Vihear became a flashpoint for nationalist sentiment in both Thailand and Cambodia. These tensions culminated on 15 July 2008 with the arrest of three Thai protesters for entering the temple grounds without authorization. Reports also indicated that Thai soldiers crossed the border and exchanged fire with Cambodian troops. Both countries responded by sending troops to the border and by October 2008, each side had over 1,000 soldiers present.

Over the next three years, multiple incidents occurred that led to both Thai and Cambodian casualties. The majority of these casualties involved patrols encountering each other in contested territories or injuries from landmines. However, it is unclear if these landmines were placed after July 2008. The Khmer Rouge occupied the area around the temple until the late 1990s, and it is possible that some mines may have been placed as early as the 1970s.

The largest skirmish occurred on 4 February 2011. Over a three-day period, multiple clashes occurred, some involving tanks and artillery. Reports indicate that at least two Thai tanks were destroyed and 33 Thai soldiers killed. It is unclear how many Cambodian casualties resulted from this skirmish. Fighting took place over a front stretching the ten kilometers from Phu Makua Hill to the Village of Phrum Srol; several Thai civilians were among the casualties. A BM-21 missile attack was also reported near the village of Sao Ton Chai in Thailand.

Throughout the conflict, each side maintained a force of approximately 1,000 soldiers in the area around the temple, where the vast majority of military incidents took place. As the conflict primarily occurred in the immediate vicinity of Preah Vihear Temple, analysis was entirely focused on the temple and the surrounding area. Imagery from throughout the conflict was acquired at three locations (Figure 14). The first location, Preah Vihear West, includes the temple, the Cambodian countryside immediately south of the temple, and Phu Makua hill. The second location, Preah Vihear East, includes the hill immediately to the east of the temple. The final location was the Thai town of Phrum Srol, situated northeast of the temple.
FIGURE 14: Preah Vihear Temple And The Surrounding Area

Sources: DigitalGlobe TANA, ESRI, USGS and NOAA
FIGURE 15: Construction of roads on Phu Makua Hill. Between 22 July 2008 (A) and 13 November 2008 (B), a new road leading west was constructed on the south face of Phu Makua Hill. By 24 April 2009 (C), the road was extended north and a second road, parallel to the first, was constructed. By 26 October 2009 (D), the first road was extended further north and a third road leading south from Thailand was observed. By 13 November 2010 (E), the road from Thailand has been extended south. Images DigitalGlobe / Analysis AAAS. Coordinates 14.4039 S, 104.654 E.
Motivations and Significance

The conflict between Cambodia and Thailand over the Preah Vihear temple originated in the treaties signed between France and Siam in the early 20th century. The two states initially agreed that their border would follow the watershed line between the Nam Sen and Mekong river basins, but the survey that demarcated the border placed the temple in French territory despite it being situated on the Siamese side of the line. In 1959, Cambodia brought suit in the International Court of Justice (ICJ) after Thailand occupied the temple site. The ICJ ruled that the temple was in Cambodia but left the status of the area around the temple unresolved. From this it can be argued that the root cause of conflict between Cambodia and Thailand began with inconsistencies in the implementation of the 1907 pact between Siam and France and continued with the ambiguous ICJ decision in 1962.

The immediate cause of the 2008 conflict, however, was the decision to inscribe the temple as a UNESCO World Heritage Site. Though there were tensions at the turn of the millennium over management of the site, an agreement signed in March 2004, and statements made by Thailand’s Prime Minister Sunaravej in 2008 paved the way for what would have been a peaceful inscription. This was a priority for Cambodia, as the temple and the surrounding mountains were some of the last areas controlled by the Khmer Rouge. Inscription as a World Heritage Site would be a powerful demonstration of control of the area.

In Thailand, the issue soon became a fault line in the long-running political dispute between rural and urban factions. The Sunaravej-led People’s Power Party (PPD) was considered a proxy for the deposed Prime Minister Thaksin Shinawatra. The opposition, People’s Alliance for Democracy, accused members of the PPD of selling Thai heritage sites to Cambodia. On 7 July 2008, the Thai Central Administrative Court ruled that the government’s decision to allow Preah Vihear’s inscription to go forward violated the national charter because parliamentary approval was not sought. On 7 July 2008, the Thai Central Administrative Court ruled that the government’s decision to allow Preah Vihear’s inscription to go forward violated the national charter because parliamentary approval was not sought.

The domestic politics surrounding Preah Vihear in both Cambodia and Thailand were characterized by nationalist impulses. In Cambodia, it represented a tangible way to assert control over an area recently occupied by a rebel group. In Thailand, opposition groups used the temple as a symbol of government corruption and held the inscription up as an example of the PPD selling the country’s heritage for personal gain.

Manifestations

Though there are some tourism related benefits to control of the Temple, the primary driver of the conflict was domestic politics rather than inherent economic worth or national security implications. As a result, neither side deployed large numbers of troops or significant equipment. Instead, analysis indicates that the conflict manifested itself largely in the creation of infrastructure and damage to civilian structures.
FIGURE 17: Potential military camp near Phrum Srol. A potential camp was constructed near Phrum Srol between 13 November 2008 (A) and 8 November 2009 (B). Three earthen berms protect structures (red arrows). The camp was present on 10 February 2011 (C), but the three structures had been removed (red arrows). By 7 February 2012 (D), the structures had been rebuilt (red arrows). Images DigitalGlobe | Analysis AAAS. Coordinates 14.3717 S, 104.721 E.

FIGURE 16: New and removed structures on 24 April 2009. On 24 April 2009, the removed structures (red dots) were concentrated in the temple market area, while the new structures (purple dots) were dispersed throughout the temple site. Images DigitalGlobe | Analysis AAAS. Coordinates 14.3956 S, 104.679 E.
Throughout the conflict, Cambodia constructed and improved several roads around the Temple. Prior to this, the main way for tourists to access the Temple was through Thailand. Cambodia improved the main road to the Temple, constructed a new road leading to a set of stairs leading up to the Temple from the east, built a large parking lot at the base of the main Temple road, and improved several other roads in the area. In addition, both Cambodia and Thailand constructed new roads leading into contested territory west of the Temple (Figure 15).

Civilian structures were also damaged during the conflict. Much of the damage was concentrated near a market situated directly north of the Temple. Between 13 November 2008 and 24 April 2009, a cluster of 27 structures was removed from the market area. Further damage was observed on 10 February 2011, immediately following the heaviest fighting of the war (Figure 16).

Despite the small number of troops deployed, two possible military camps were observed on the Thai side of the border. One was situated 7 km northeast of Preah Vihear Temple and included multiple structures arranged in a small circle surrounded by a fence. The second installation was observed east of Phrum Srol and includes multiple structures, three of which were enclosed in earthen berms (Figure 17). In both cases, the layout of the camps was not similar to any other compounds or groups of structures observed in the area.

**Summary of Findings**

Multiple roads were constructed and improved in the area around Preah Vihear Temple over the course of the conflict. Cambodia improved access to the Temple by widening the main road leading up to the Temple’s promontory. This included the creation of switchbacks and the construction of bridges. The road leading to the eastern staircase was also expanded. A third road, east of the Temple and leading north to the border with Thailand, was also improved. The road was widened and ten new bridges were constructed. In addition, several other new roads were observed in the area south of the Temple, as well as leading up to Phu Makua hill.

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**TABLE 1:** Structures removed and added to the area around the temple
The construction of roads, particularly on the Cambodian side of the border, demonstrates the importance of controlling area around the Temple to conceptions of Cambodian statehood. By constructing several new roads, and improving others, Cambodia was tangibly asserting control of a border region that until recently, had been occupied by the Khmer Rouge. Improving access to the Temple from Cambodia also demonstrates Cambodia’s commitment to developing Preah Vihear as an international tourist destination.

In addition to the construction of roads, the number of structures present on the Temple promontory changed throughout the conflict. There were two periods of time when large numbers of structures were removed (Table 1). The first occurred between 13 November 2008 and 24 April 2009, when a nearby market was demolished. The second occurred between 13 November 2012 and 10 February 2011, when, 84 structures were removed. There were also three periods of time when large numbers of structures were added, between 13 November and 24 April 2009, between 26 October 2009 and 12 November 2010, and between 1 March 2011 and 22 February 2012.

The first observed loss of structures was likely the result of a series of events that occurred on 3 April 2009. Thai rockets reportedly struck the market area and it was reported that Thai soldiers stopped residents from extinguishing the resulting fires. Residents of the village who lost their homes were then moved to a temporary camp 10km away. The new structures observed in the same time period were scattered throughout the promontory. The reason for the construction is unknown but it is possible that these were constructed by residents who chose not to be relocated, or, that the structures were used as part of the subsequent investigation of the incident.

Media reports indicate that construction of a new market began in July 2009. This may account for the 76 new structures that were observed between 26 October 2009 and 13 November 2010. The next major event was the removal of 84 structures between 13 November 2010 and 10 February 2011. This time period coincided with the heaviest fighting of the conflict, which likely contributed to the loss of structures. The new structures constructed before 22 February 2012 may have been a result of rebuilding efforts following the February 2011 fighting.

Cambodian villages were also removed from the area but the reasons for these removals could not be determined with satellite imagery. Almost all of the structures of the village of Angkrong were removed between 26 October 2009 and 13 November 2010. The circumstances behind this removal are unclear. No craters or other signs of fighting were observed in the village during this time.
period. In addition, the village does not lie within the Temple’s view-shed as mapped in the UNESCO application, so it is unlikely that the removal of the village was related to the Cambodian plans to manage the Temple site.  

Finally, though each side deployed approximately 1,000 troops to the area during the conflict, only two potential military camps were observed; both in Thailand. Though no obvious military equipment was observed at either camp, their layouts strongly suggest that they were military in nature. It is important to note that heavy tree coverage in the area may have obscured smaller camps or military positions. Reports indicated that Cambodia stationed troops at the Temple itself. Therefore, it is possible that some of the new structures observed on the promontory could have housed military personnel.

In total, analysis revealed few changes in the period leading up to the February 2011 skirmishes that would indicate the skirmish was imminent. Only a small number of troops were deployed to the area by either side, making monitoring military encampments difficult. The dense forest canopy of the area also hindered the detection of military equipment. Furthermore, reports indicate that many skirmishes were the result of random events, such as patrols encountering each other or the explosion of a landmine.  

Due to these facts, remote sensing provided little information concerning the possibility of the outbreak of violence, but provides insight regarding factors that may hinder, complicate, or prevent monitoring.

Conflict Resolution

On 28 April 2011, Cambodia formally requested that the ICJ clarify the 1962 ruling. Pending the clarification, the ICJ ordered troops from both countries to withdraw from the Temple area. On 11 November 2013, the ICJ ruled that Cambodia had sovereignty over the Temple promontory but left the status of the surrounding area unresolved. No further conflict has occurred near the site since the ruling and Preah Vihear Temple continues to be listed as a UNESCO World Heritage Site.

Early Warning Signs

In the Cambodia-Thailand border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the construction of new roads leading towards the temple; and
- the construction of military encampments.
India and Pakistan: 2001–2002

Introduction
Perhaps no international border is as fraught with as much ongoing conflict as the one separating India and Pakistan. Even the demilitarized zone separating the Koreas, often cited as the archetypical example of cross-border acrimony, has been essentially static for over sixty years, while during a comparable period of time tensions along the border between India and Pakistan have erupted into full-scale war on four separate occasions: in 1947, 1965, 1971, and 1999. On 13 December 2001, this already tense situation was significantly exacerbated when gunmen linked to the Pakistani militant group Lashkar-e-Taiba attempted to storm the Indian parliament following a joint session of the legislature, killing five guards, two employees, and directly threatening the integrity of the Indian government. In the words of Indian National Security Advisor Brajesh Mishra, “in January...we were on the point of launching a full-scale war.” A senior Indian army officer in Punjab echoed these sentiments saying, “By the 6th, we were 100% prepared.”

Motivations and Significance
Although the 2001-2002 standoff ended without escalating into all-out war, it was the most serious of the India/Pakistan disputes that have taken place since the widespread availability of satellite imagery, and the preparations made by both militaries moved the situation to the brink of full-scale war. These mobilizations are instructive, because both Indian and Pakistani political leaders admitted that war between the two countries was a very real possibility in the first half of 2002, and as such, they are likely identical to what would have taken place in the event of an outright conflict. The potentially severe consequences of a war between two densely populated nuclear powers scarcely need to be mentioned. Furthermore, as demonstrated by the 2008 Mumbai attacks and subsequent standoff at the border, there is no guarantee that similar events will not happen in the
FIGURE 18: Locations imaged in India and Pakistan
FIGURE 19: Aircraft movements and air-defense construction at PAF Base Minhas. At PAF Base Minhas, aircraft that were parked in the open prior to the crisis (A) are no longer visible during the period of heightened tensions with India (B). Over the same period, anti-aircraft artillery has been installed at the end of the base’s runway (C-D). Images DigitalGlobe | Analysis AAAS. Coordinates: 33.87 N, 72.40 E.

FIGURE 20: Halwara AFS, India, near the Pakistani Border. Clockwise from top left: A Sukhoi Su-30 MKI (bottom arrow), India’s most advanced jet fighter, takes off from runway 31 at Halwara AFS, casting a visible shadow on the ground (top arrow); two Su-30MKIs parked near aircraft shelters at Halwara AFS; Indian Air Force MiG-23 BNs parked near hangars at Halwara AFS. Images Digital Globe | Analysis AAAS. Coordinates: 30.75 N, 75.63 E.
The events of 2001-2002 provide an excellent opportunity to study the nature of conflict along this volatile border. An initial survey of the border area identified 26 sites that were evaluated as favorable candidates for exhibiting signs of the reported buildup. These included army bases and cantonments in both India and Pakistan, as well as airbases, and military facilities along the border itself. In most cases, multitemporal coverage from both before and after the standoff was available, enabling the most accurate possible assessment of the state of affairs. In rare cases, areas were also included despite only a single image being available, due to their potential strategic significance. Of the ten army and air force bases in northwest India imaged in this study, three were located in Punjab, one in Haryana, one in Uttar Pradesh, and two in the disputed territory of Jammu and Kashmir. In Pakistan, all military installations were located within that country’s Punjab province.

**Manifestations**

Analysis of the imagery revealed a number of phenomena consistent with large-scale military mobilization, including the construction of perimeter defenses around military installations, the erection of surface-to-air missile batteries, and the redeployment of ground-based forces. The extent and nature of these observations are discussed below, and are illustrated in Figures 19 through 22.

**Indian Air Force (IAF) Stations**

As would be expected, analysis of Indian and Pakistani Air Force stations revealed large numbers of military aircraft. Determining whether these observations represented an increase over the bases’ peacetime deployments, however, was problematic, as both India and Pakistan make extensive use of hangars to protect their aircraft from the elements. Where visible, military aircraft in both countries were observed to change position, indicating the likelihood that most are in operational condition. In many cases, however, the long duration between “before” and “after” imagery rendered any assessment of recent operational deployments problematic. While it was difficult to draw firm conclusions from counting aircraft, however, other observations at airbases revealed trends suggesting the increasingly tense geopolitical situation. These included the construction of new anti-aircraft defenses (Figure 17), and, in the case of India, the deployment to the border of its latest and most capable air superiority fighter, the Su-30MKI (Figure 18). The presence of this fighter is of particular interest, as it represented the most modern of all IAF fighter aircraft. India’s first squadron of the aircraft only became operational on 27 September 2002, a mere three days prior to the image’s acquisition. Contemporary media reports indicate that that squadron was based at Pune airbase on India’s southwestern coast. Whether the aircraft were temporarily assigned to the border for potential combat duty or were simply visiting as part of a training exercise is unclear, however the appearance of these advanced new fighters in Punjab during a period of elevated border tension can hardly have gone unnoticed by Pakistan – a fact of which the IAF was surely aware.

**Army Bases**

In both India and Pakistan, observations of army bases and cantonments revealed trends consistent with a large-scale redeployment of forces. On the Indian side, the army bases in Punjab and Haryana were considered excellent targets for imaging due to their strategic location in the lowlands between the Indian capital and the Pakistani border. Although tanks and artillery are smaller and less obvious than aircraft, the movements of such assets are no less useful from an analytical point of view. For example, at

FIGURE 22: Vehicles and artillery vanish from Jhelum, Pakistan. At Jhelum cantonment, India, a comparison of pre-crisis and post-crisis imagery reveals that large numbers of vehicles (A, B) and artillery (C, D) were removed from outdoor storage depots. The presence of a military convoy on the streets near the facility (E) suggests that this phenomenon is related to redeployments associated with the ongoing border conflict. Images Digital Globe | Analysis AAAS. Coordinates: 32.92 N, 73.71 E.

FIGURE 23: Defensive earthworks and probable mortar positions along the border. Images Digital Globe | Analysis AAAS. Coordinates: 31.73 N, 74.50 E.
Jalandhar Cantonment, the headquarters for the Indian Army’s XI corps, analysis revealed parking lots and depots full of vehicles and artillery pieces in pre-crisis imagery from early 2001. By the summer of 2002, however, nearly all of these had disappeared, as would be expected if they had been deployed to the front lines of the conflict (Figure 21). During the same period, air defenses were also constructed at the base and a number of helicopters were observed that had not previously been present. Similar observations were made at bases across India, where hundreds of tanks, artillery pieces, and logistics vehicles that were visible in pre-crisis imagery were no longer visible in imagery taken during the buildup. Unlike at airbases, in most cases these depots lacked the covered shelters that made analysis of airbases problematic.

With its capital resting less than one hundred kilometers from the line of control, Pakistan places enormous emphasis on the defense of the plains of Punjab, and has constructed many army bases in the area. Observations of Pakistani army bases largely mirrored their Indian counterparts. For example, at Mangla Cantonment, located 75 kilometers southwest of Islamabad, it was observed that hundreds of trucks and other logistics vehicles disappeared from parking lots and vehicle depots throughout the base between September 2001 and the end of January 2002. This scene repeated itself at bases throughout Pakistan; for example, at Jhelum Cantonment, 25 kilometers south of Mangla Cantonment, large numbers of trucks were observed in pre-crisis imagery, along with a number of pieces of field artillery. By January 2002, however, the artillery and many of the trucks had disappeared, and a convoy of military vehicles was seen on the streets immediately adjacent to the base (Figure 22).

Not all bases exhibited this effect, however. Notably, Rawalpindi cantonment showed little to no visible activity in the three images that were acquired of it. One explanation for this lack of a result may be that, as the general headquarters of the Pakistani army, Rawalpindi cantonment may be more focused on command and control than on the logistical elements of military affairs. Muree cantonment, located north of Islamabad near the disputed territory of Kashmir, also showed no visible activity – a finding that is consistent with the lack of a noticeable increase in militarization observed along the northern border on the Indian side, at Siachen Glacier.

Border Regions

Despite the reportedly intense militarization that took place along the border, attempts to image the frontier directly returned little usable information – particularly when compared to the large areas covered by each image. There are several possible explanations for this, which need not be mutually exclusive. First, the border between India and Pakistan is 2,900 kilometers long, and even large numbers of troops and equipment will necessarily become less dense when dispersed along such a frontier. Second, when in the field – and particularly in crisis situations – militaries often go to great lengths to conceal and camouflage their positions. Finally, the area that was imaged represents only a very small fraction of the entire border. Although much research went into determining which locations along the border were most likely to reveal significant deployments, it is possible that the bulk of the mobilized forces were located elsewhere. Nevertheless, some relevant observations were made in the border areas. In the section of the border 20 kilometers northeast of Lahore, for example, freshly constructed earthworks were visible on the Indian side of the border, with a small cluster of vehicles concealed directly behind them. Nearby, on the Pakistani side, several small mortar emplacements were observed in agricultural fields (Figure 23).
Summary of Findings

Despite their large size and easily identifiable shapes, analysis of aircraft deployments appears to be an unreliable metric for interpreting conflict along the India-Pakistan border. Due to the top-down perspective afforded by satellite imagery, the use of hangars or other shelters that obstruct the view of aircraft from above are extremely effective at limiting the usefulness of such methods. Even if not being used, the mere presence of such facilities at an airfield vastly increases the uncertainties associated with aircraft counts, as each such shelter represents at least one aircraft – and often many more – that may or may not be present. Furthermore, if a commander’s goal is to limit the exposure of their aircraft to possible enemy fire, the dispersal and/or concealment of those assets in hangars or hardened shelters makes good tactical sense during a crisis situation. Despite these problems, when they are sighted, aircraft are sometimes capable of providing useful information. This was the case, for example, with the detection of the top-of-the line Su-30MKIs at an airfield far from their home base, and intimidatingly close to the Pakistani border.

Analysis of ground-based assets shows considerably more promise as an indicator of heightened tension. Unlike aircraft, large numbers of transport, logistics vehicles, and artillery in Indian and Pakistani military bases are stored in outdoor depots during peacetime. In times of crisis, however, these facilities appear to empty themselves regardless of upon which side of the border they are located. Presumably, this phenomenon reflects decision-making on the part of Indian and Pakistani military planners, and manifests itself when the absent vehicles and weapons shift from being held in reserve to being forward deployed – a conclusion supported by the observation of a moving military convoy outside Jhelum Cantonment. Both air force and army bases also often saw the construction of new anti-aircraft batteries, which can be interpreted as a sign of increased expectation of aerial attack.

When studying a border as long as the one that separates India from Pakistan, imaging of the entire border area is impractical without an extremely large budget for data acquisition and analysis. Attempts to sample the border at areas that were thought likely to show signs of tension were partially successful, however only a small number relevant observations were generated using this method – a result that may be due to the concealment and dispersal of forces, as well as the large size of the border region relative to the area that was studied. Due to the cost of the imagery and the length of time required for the analysis of such large areas, this technique is less effective than methods that involve the targeting of known military facilities.
Monitoring ground forces is particularly useful – especially those bases known to contain artillery and armored forces. Airbases tend to produce more ambiguous results due to the lower numbers of assets, and high potential for concealment.

Conflict Resolution

In late 2001 and early 2002, India and Pakistan went to the brink of what would have been their fifth war in fifty-four years. The standoff was the result of a long-running territorial dispute between India and Pakistan that dates back to the partition of British India. India’s mobilization was a direct consequence of the assault on that country’s parliament. The goals of the Indian deployment appear to have been twofold: retaliation for the attack, and deterrence against subsequent strikes. In particular, India’s strong response appears to have been directed at the Pakistani government, which many in India believed to have tacitly or explicitly encouraged the perpetrators of the parliament attack. In this context, the military escalation may have been engineered to discourage the Pakistani government from involvement with militant groups such as Lashkar-e-Taiba. Pakistan’s response to the Indian deployment and the subsequent war of words that resulted are highly significant, as it represented the closest the two powers had come to a military conflict since they both became nuclear powers in 1998. Both sides engaged in escalating rhetoric against the other as the standoff continued, and actors in both India and Pakistan exploited the conflict for internal political purposes. In such a charged and unpredictable atmosphere, the potential consequences of miscalculation or misreading of the intentions of the opposing side were severe.

That the crisis ultimately was resolved before it escalated into full-scale war does not diminish its utility as a tool for studying border conflict, as words and actions from both sides reinforce the conclusion that war between two hostile and nuclear-armed powers was a very possible outcome. Following multiple rounds of shuttle diplomacy, U.S. Deputy Secretary of State Richard Armitage, acting as a mediator between the two sides, secured commitments from Pakistani President Pervez Musharraf to halt cross-border attacks by militants based in Pakistan. Following this breakthrough, tensions gradually decreased along the India/Pakistan border during the autumn of 2002, culminating in India withdrawing its forces from the border on 16 October.

Early Warning Signs

In the India-Pakistan border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the deployment of troops and fighter aircraft to the border; and
- the movement of logistics materiel and vehicles from depots.
At first glance, the conflict between India and Pakistan appears to have little in common with the skirmishes between Cambodia and Thailand over the Preah Vihear Temple. Even more so than for the African case studies, the scale of hostilities varied enormously between the two pairs of belligerents. Pakistan and India are major regional powers equipped with nuclear weapons and large standing armies, supported by populations numbering in the hundreds of millions and the billions, respectively. The standoff of 2001-2002 posed a major national security threat to both countries, and dominated the decision making of the military and civilian leadership in both countries for months.

In contrast, Cambodia and Thailand are much smaller states, with populations of 15 million and 67 million people, respectively. Their militaries are also much smaller and less modern than India’s and Pakistan’s. The Cambodian Army officially has approximately 100,000 soldiers, though some estimates place the real number at closer to 60,000. It has a small number of older Soviet tanks and no significant air force. Thailand has a larger, more modern military than Cambodia, including tanks and a small air force. However, other military concerns precluded the deployment of a large number of forces to the Cambodian border. The Thai army is divided into four military districts: Northern, Central, Southern, and Northeastern. The Central district includes Bangkok, and a large portion of the military remains near the capital to prevent domestic unrest. The Northern district border contains the second largest number of soldiers because of instability along the border with Burma. Addressing ethnic unrest in the south is a third priority for the military, leaving the Northeastern district with the smallest number of troops. As a result, though the conflict over Preah Vihear was politically important, it was not a major priority for either country’s military.

In the images analyzed in this report, these differences in scale led to the two conflicts manifesting themselves in very different ways. In Cambodia and Thailand, the small number of troops deployed by both sides meant that there was no large scale mobilization of troops from military bases to the border. The major observation was the expansion of the road network in the area as both countries used infrastructure to assert control of the border.

Unlike in southeast Asia, the transportation infrastructure along the India/Pakistan border was already developed; new roads did not need to be constructed in order to transport troops and supplies. Similarly, the deployment of heavy transport vehicles, tanks, artillery, and jet fighters observed in India and Pakistan was strikingly unlike anything seen near Preah Vihear. Finally, the conflict between India and Pakistan has a large ethnic and religious component that is lacking between Cambodia and Thailand.
The importance of this element of the India/Pakistan standoff cannot be overstated; inter-religious violence and militant rhetoric has a long history in both India and Pakistan.\textsuperscript{50} The effects of this phenomenon on the military and policymakers is difficult to gauge, but given the potential consequences of a miscalculation between nuclear powers, should not be understated.

Despite the vast differences in scale, severity, and socioreligious context that separate the two conflicts, they do nevertheless possess common elements. Both, for example, have their origins in a long-running territorial dispute dating back to the colonial era. When Great Britain granted independence to the colonies of British India, its rulers attempted to partition the territory along religious lines, thereby creating the states of India, Pakistan, East Pakistan (now Bangladesh), and Sri Lanka. The status of the princely states of Jammu and Kashmir, however, was left unresolved, and both India and Pakistan immediately claimed both in their entirety, sparking the conflict that continues to this day.

Arguably, both disputes also involved the channeling of internal tensions within their respective countries toward an external enemy. In the case of Cambodia and Thailand, this expressed itself through a number of events including ethnic riots in Bangkok and Phnom Penh, the ruling by the Thai Central Administrative Court in 2008, and the occupation of Preah Vihear by Thai protesters, which ignited the conflict. In the India/Pakistan conflict, both governments also had domestic political motives to direct the public’s attention abroad. Following the attacks of September 11th, just three months prior to the crisis, Pakistani President General Pervez Musharraf had supported the American invasion of Afghanistan – a move that was deeply unpopular with the Pakistani public. In India, activists from the right-wing Hindu nationalist organization Vishva Hindu Parishad harshly criticized the government of Prime Minister Atal Vajpayee, accusing him of vacillating on the building of a Hindu temple atop the site of a former mosque that had been demolished in 1992.\textsuperscript{51,52} Lastly, both situations were diffused through diplomatic mediation by external actors. In India and Pakistan, this took the form of intervention by U.S. Deputy Secretary of State Richard Armitage. The situation between Cambodia and Thailand was resolved through mediation by Indonesia and the Association of Southeast Asian Nations.
Russia and Georgia: 2008

Introduction

In 1991, the fall of the Soviet Union led to the creation of 15 new independent states. As part of the Soviet Union, these states had shared a majority of their infrastructure, including military, transportation, communication, energy, and financial systems. As a result, they were forced to maintain some degree of cooperation to manage their shared assets. It was initially hoped that these shared assets would help foster the creation of a common economic space, perhaps similar to the European Union.

In the Caucasus region, however, the dissolution of the Soviet Union led to the renewal of dormant conflicts. Two regions in Georgia, South Ossetia and Abkhazia, had advocated for autonomy from Georgia during the Soviet Era. Between 1991 and 1993, Georgia fought wars over the status of these regions. As a result of the conflicts, both areas became semi-autonomous regions in Georgia, patrolled by a largely Russian peacekeeping force.

Though there were initial signs for optimism about the relationship between Georgia and Russia, after independence relations quickly deteriorated. In the mid 1990’s, the Russian Douma failed to ratify several treaties, including the 1994 Georgian-Russian Friendship Treaty. The resurgence of a Chechen separatist movement further strained relations as Russia accused Georgia of harboring terrorists. Tensions eased as Georgia agreed to jointly patrol the border with Russia, but the decision alienated Georgian nationalists.

By the start of the 21st century, Georgia was improving its relations with the west. For example, in November 2002, President Shevardnadze officially requested that Georgia be invited to join NATO, which led to increased tensions in Russia. The relationship was further inflamed by the 2004 terrorist attack on a school in Beslan, North Ossetia, during which initial Russian statements implied that Georgia was partially responsible.

Over the next four years, tensions remained high as Georgia and Russia traded accusations of sabotage and spying. In October 2007, Georgia withdrew its agreement for the presence of peacekeepers in Abkhazia after Russian soldiers allegedly beat Georgian police officers. In March 2008, Russia lifted trade, financial, and transportation sanctions on Abkhazia and, in April, deployed an additional 1,500 peacekeepers to the province without consulting Georgia. At the same time, violence escalated in South Ossetia as Georgian troops and South Ossetian militia forces skirmished throughout the summer.

In July 2008, both Russian and Georgian forces were engaged in large scale training maneuvers near their shared border. None of the troops returned to their barracks following the maneuvers, with Georgian forces concentrated around Gori and Russian troops remaining near the Roki Tunnel, which connects South Ossetia to Russia. Between 1 August and 7 August 2008, the frequency of skirmishes increased as both sides prepared for war.
FIGURE 24: Site Locations
FIGURE 25: Damage to civilian structures East of Tskhinvali. On 10 August 2008, a small number of structures (orange circle) had been damaged but by 19 August 2008, almost all had (red dots) Image DigitalGlobe | Analysis AAAS. Coordinates 44.242 N, 44.035 E.

FIGURE 26: Damage to the Senaki runway. Multiple craters were observed on and around the runway on 22 August 2008 (B) including several linear stripes crossing the runway (blue arrows). Images DigitalGlobe | Analysis AAAS. Coordinates 42.24 N, 42.05 E.
On 5 August, civilians in Tskhinvali were evacuated. On 7 August, Georgia had amassed 12,000 troops on the border with South Ossetia and South Ossetian villages reported being struck by artillery.\textsuperscript{62,63} Georgia claims to have received intelligence reports that Russian troops entered the Roki Tunnel on 7 August and began shelling Tskhinvali shortly before midnight. By 2 am, western news outlets received reports that Russian tanks had entered the Roki Tunnel.\textsuperscript{64} Over the next five days, Russian troops drove Georgian forces from South Ossetia and occupied multiple military bases in western Georgia, outside of Abkhazia.

Imagery of seven sites in Georgia and Russia was acquired to analyze the conflict (Figure 24). Three of these sites were Georgian military bases while three were Russian military bases in southern Russia. Imagery of the Roki Tunnel, which connects South Ossetia to Russia, was also acquired.

**Motivations and Significance**

The causes of the five-day war are complex and multifaceted, owing to differing perceptions about Abkhazia and South Ossetia in Georgia and Russia. To Georgia, the two breakaway regions represented a threat to the unity and stability of the Georgian state. In the years prior to the war, various Russian actions could be interpreted as pushing for full autonomy of the two regions. These actions included lifting sanctions on Abkhazia and providing Russian passports to residents of South Ossetia and Abkhazia. As the areas drifted under Moscow’s influence, the unification of Georgia and the two regions may have appeared increasingly unlikely to ever occur.

In Georgia, the decision to escalate tensions in the face of overwhelming Russian military superiority may have reflected a “now or never” attitude toward the two regions. It has also been proposed that the war served a diversionary purpose in Georgia; President Saakashvili may have hoped to use conflict with Russia as a method of generating domestic support.\textsuperscript{65}

It can also be argued that the conflict also was indicative of Moscow’s use of external scapegoats along with conflict with the west as a method of maintaining political power. The Russian response to the Beslan attack, which implied Georgia was partially to blame, is an example of blaming outside actors for domestic unrest in the Caucasus. This may have contributed to anti-Georgian sentiments within Russia, allowing Moscow to assert itself as the legitimate defender of Russian speakers in the region.\textsuperscript{66}

Georgia’s Rose Revolution and subsequent shift towards a western orientation was also a source of tension. Georgia’s announcement of its intention to join NATO, and involvement in the Baku-Tbilisi-Ceyhan pipeline raised concerns about a western presence along Russia’s southern border. Russia has historically considered the Caucasus as within its sphere of influence so these actions represented the encroachment on the region by foreign powers.
Manifestations
The primary manifestation of the conflict was the war itself. This led to the defeat of Georgian military forces, the destruction of civilian structures, and population transfers, since much of the small remaining population of ethnic Georgians fled from South Ossetia and Abkhazia into Georgia proper. Analysis conducted by the AAAS Geospatial Technologies and Human Rights Project in 2008 documented the destruction of civilian structures in 24 village areas around Tskhinvali (Figure 25). The damage was initially concentrated around Tskhinvali, but by 19 August, several outlying villages had also suffered significant damage. In total, the project observed damage to over 600 civilian structures. The AAAS report is being used by the European Court for Human Rights as part of ongoing litigation regarding the war.

During the conflict, the Georgian military was defeated. Russian forces occupied many military bases west of Tbilisi, including at Gori and Senaki. In addition, the Black Sea Fleet successfully blockaded Georgian ports. At the Senaki airbase, the effects of the occupation were directly observed with satellite imagery. On 22 August 2008, imagery revealed multiple craters near the runway, including several linear strips of damage that crossed the runway (Figure 26).

Summary of Findings
Satellite imagery analysis of the 2008 war between Georgia and Russia was hampered by the lack of available imagery. This was confounded by the fact that Russia had a large number of small military installations throughout the Caucasus. As a result, acquiring imagery of every potential site was prohibitively expensive. When imagery of sites did exist, there were often long periods of time between images. This, combined with the short duration of the conflict, made it difficult to determine which activities at the various military installations were associated with the conflict. For example, similar numbers of trucks were observed in Botlikh on 22 January 2008 and 22 December 2008, but many were parked in slightly different locations. The lack of available imagery from the intervening months made it impossible to determine when different vehicles were moved.

Despite these limitations, certain phenomena were observed that suggest that, with more imagery, more information about the conflict could have been constructed via satellite imagery. For instance, multiple tanks and vehicles were observed on both sides of the Roki tunnel on 18 August 2008. If more frequent imagery had been available from the days immediately preceding the conflict, it may have been possible to establish a timeline of Russian troops movement towards the tunnel.
Similarly, observation of the Georgian military base at Vaziani revealed large movements of materiel between 31 December 2007 and 24 March 2008. As the next available image was captured on 18 August 2008, it was impossible to determine if more materiel were moved on and off the base in the intervening months, including in the weeks leading up to the conflict. This lack of imagery made it difficult to monitor preparations made by Georgia and Russia prior to the start of the conflict.

**Resolution**

On 12 August 2008, French President Sarkozy, acting as President of the Council of the European Union, mediated a ceasefire agreement between Georgia and Russia. However, reports indicated that Russian and South Ossetian forces continued advancing into Georgian territory until 16 August. By 22 August, the majority of Russian troops had withdrawn to the administrative boundaries of South Ossetia and Abkhazia, though some remained in buffer zones outside of the regions. On 9 October 2008, the Russian Foreign Ministry officially announced the complete withdrawal of Russian forces from these buffer zones.\(^6^8\) In addition, Russia officially recognized Abkhazia and South Ossetia as independent states on 26 August 2008.\(^6^9\) Georgia continues to take the position that provinces are Georgia territory, but at present, they operate with autonomy from Tbilisi.

**Early Warning Signs**

In the Georgia-Russia border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the deployment of troops to the Roki Tunnel; and
- the movement of logistics materiel and vehicles.
Introduction

Nagorno-Karabakh is a mountainous region in the South Caucasus situated roughly 100 kilometers southeast of the Armenian capital, Yerevan. Although inhabited largely by ethnic Armenians, during the Soviet period the region was an administrative division of the Azerbaijan Soviet Socialist Republic (SSR) known as the Nagorno-Karabakh Autonomous Oblast (NKAO). For most of that era, however, the long-standing ethnic tensions that existed between Armenians and Azeris in the region were effectively suppressed by the Soviet authorities. With the reforms of Glasnost and Perestroika in the late 1980s, this situation changed, and public demonstrations both for and against the oblast’s cession to Armenia occurred frequently.70

In the town of Askeran, these events turned violent in early 1988, when confrontations between the Armenian population and a crowd of Azeris from nearby Agdam ended with two Azeris killed under unclear circumstances. This clash was followed by a pogrom against ethnic Armenians living in Sumgait, a suburb of the Azerbaijani capital of Baku. In Armenia, outrage over the events in Sumgait combined with frustration over Moscow’s decision on 23 March not to cede Nagorno-Karabakh to Armenia, and led to the massive expulsion of Azeris living in Armenian territory, including the burning of nine villages. In Azerbaijan, fearing reprisals, many ethnic Armenians began to flee the country.71

In June, the Soviets of the Armenian SSR and Azerbaijani SSR held votes with mutually contradictory outcomes regarding the status of the Nagorno-Karabakh Autonomous Oblast, prompting Soviet leader Mikhail Gorbachev to publicly reject any change in the USSR’s internal borders at a party congress in Moscow. This led the Karabakh Armenians to unilaterally vote for secession from Azerbaijan on 12 July 1988. In November, following the sentencing of an Azeri involved in the violence in Sumgait, a new wave of violence and expulsions erupted against Armenians in the Azerbaijani cities of Baku and Ganja. By the end of the month, roughly 400,000 refugees had been exchanged between Armenia and Azerbaijan, in nearly equal proportions.72

As the Soviet Union became increasingly unstable, the situation in Azerbaijan and Armenia progressively deteriorated. Armenian and Azeri militias continued to stockpile arms and sporadically attack one-anther, defying the authority of an increasingly ineffective government in Moscow, which was no longer able to enforce stability. In September 1991, the Soviet of the NKAO issued a proclamation declaring the oblast’s independence as the Nagorno Karabakh Republic (NKR). Soviet forces withdrew from the region in December 1991. With their departure, the crisis between Armenia and Azerbaijan quickly escalated into open warfare.73
FIGURE 27: Overview of the areas imaged in Armenia and Azerbaijan
The outbreak of war was a disaster for Azerbaijan, which had assumed it would have Moscow’s support to defend Karabakh, and was left badly unprepared in the face of Armenia’s extensive military preparations. In February 1992, Armenian forces captured the town of Khojaly, a predominately Azeri village in the NKR, in an episode of ethnic cleansing that Human Rights Watch estimate resulted in the deaths of between 200 and 1,000 civilians, and the forced displacement of hundreds more.

Azerbaijan, facing severe domestic political turmoil, attempted a counteroffensive in June of that same year that resulted in limited gains that were subsequently reversed by an Armenian counteroffensive in the spring of 1993. Throughout the following year, Armenian forces accumulated a string of victories, capturing vast swaths of territory, including predominately Azeri areas outside the boundaries of the NKR. Contemporary estimates indicate that this offensive resulted in the displacement of 80,000 to 100,000 Azeris by late summer. A final Azerbaijani attempt to repel the Armenian forces was pushed back in February 1994. Following this defeat, a Russian-brokered cease-fire was implemented in May, and ratified by the parties in July 1994. Although this agreement remains in place low-intensity conflict continues, particularly along the line of contact between the opposing forces, where skirmishes and other violations of the cease-fire are commonplace.

Motivations and Significance
In keeping with many other border conflicts in the former Soviet Union, cross-border ethnic claims form a significant component of the continuing conflict. The goals of Armenia and the NKR – which is often considered a de-facto part of Armenia – are both centered on maintaining the status quo and holding the territory gained prior to the 1994 ceasefire. For Azerbaijan, the strategic calculus is driven by the desire to regain what it considers to be occupied territory. In both cases, nationalism plays a key role in the continuation of the conflict. Armenians perceive the independence of Nagorno-Karabakh as critical to their national identity, particularly in the context of the genocide of 1918, and the separation of the NKAO from Armenia during the Soviet era. For Azerbaijan, the reversal of their humiliating defeat is a matter of national pride.

Since 2000, three sets of incidents have taken place that could be studied using high-resolution satellite imagery. The first of these took place on 4 March 2008, near the town of Levonarkh in the northeast of the NKR, where a gun battle broke out along the line of contact. According to the conflicting narratives promulgated by the two sides, this clash led to the death of between 8 and 20 servicemen, with the distribution of nationalities varying from source to source. According to reports in the Armenian media, armament of an unspecified nature was left on the battlefield. Four days later, a second gun battle (with similarly unclear results) took place near Agdam, a former Azerbaijani city 35 kilometers to the south, which now lies in ruins.

In the summer of 2010, a second series of clashes took place along the line of control, this time near Chaylu, a small village located less than five kilometers from the site of the 2008 skirmishes. As before, accounts of which side fired first vary widely, with the Armenian side claiming they came under a surprise attack from an Azerbaijani unit on the night of 18 June, while the Azerbaijani government claimed that its troops were
subjected to automatic weapons fire from Armenian forces. Four Armenians and one Azerbaijani were killed in the night’s fighting. Two days later, on 21 June, Armenian forces retaliated against Azerbaijani forces near Fizuli, on the southeastern border of the NKR, resulting in the death of one Azerbaijani serviceman. Following this incident, a tense standoff prevailed along the line of contact until three Armenians and two Azeris died in an exchange of fire near the village of Jraberd on 1 September, for which each side, once again, blamed the other.

After a year of relative quiet, a third round of skirmishes broke out the evening of 4 June 2012. As in previous incidents, the sequence of events varied widely between belligerents. Azerbaijan claimed that “Armenian saboteurs” had killed four soldiers in an incident in the village of Aşağı əskipara, and a fifth in the Qazax district. Armenia, by contrast, claimed that its forces successfully fought off a group of between 15 and 20 “armed diversionists” who attempted to invade the Tavush district, adjacent to Qazax. Unlike the incidents in 2008 and 2010, which occurred along the line of contact between Azerbaijani and Armenian troops in the disputed territory, the 2012 clashes took place along the uncontested border between Azerbaijan and Armenia. Irrespective of which party fired the first shot, the spread of the conflict to areas beyond Nagorno Karabakh in 2012 represented a potentially hazardous escalation.

In order to determine whether any of these recent clashes were accompanied by warning signs that were visible in satellite imagery, AAAS acquired multiple images of the area surrounding the reported site of each skirmish. Where possible, additional imagery was also acquired of nearby military bases, as experience has shown that changes in activity at these facilities often accompanies the redeployment of forces associated with conflict. A full accounting of the imagery acquired is available in the full Armenia-Azerbaijan case study, published separately. Each of these images was visually analyzed, with particular attention paid to features that have been identified as being associated with border conflicts. These include features such as the movement of troops, logistics vehicles and materiel, the development of new infrastructure in close proximity to the disputed area, and the direct effects of weapons systems, such as damaged buildings and shell craters.

**Manifestations**

Despite careful targeting of the areas where fighting was reported, direct imagery of the border after all three clashes exhibited no significant changes from pre-skirmish imagery. Analysis of military bases, however, did reveal changes following the 2010 and 2012 incidents. In Azerbaijan, these changes manifested through the movement of artillery, armor, and logistics vehicles, and primarily took place at Perekeshkul army base outside Baku (although following the 2012 incident, activity was also visible at military installations in the city of Ganja). The changing numbers of vehicles and weapons systems at Perekeshkul in 2010 are illustrated in Figure 28. On 29 March 2010, prior to the incidents, the base contained 7 armored vehicles, 20 artillery pieces, and 91 trucks. On 1 September, after the events of June and concurrent with the re-escalation that took place in Jraberd on the same date, the base contained 15 armored vehicles, 12 artillery pieces, and 97 trucks. Following the second skirmish, on 30 September, the base contained 20 armored vehicles, 8 artillery pieces, and 110 trucks.
FIGURE 28: Changing numbers of vehicles and artillery at Perekeshkul army base, 2010. Between 29 March (top left), 1 September (top right), and 30 September (bottom left), a number of artillery pieces (yellow outline) disappear from the Azerbaijani base at Perekeshkul. Over the same interval, the number of armored vehicles (red outline) increases. Images DigitalGlobe | Analysis AAAS. Coordinates: 40.48 N, 49.59 E.

FIGURE 29: Movement of possible artillery near Yerevan. Between 16 and 21 June 2010, six possible artillery pieces (yellow arrows) are no longer visible at a base outside Yerevan. Images DigitalGlobe | Analysis AAAS. Coordinates: 40.08 N, 44.55 E.
In addition to the Azerbaijani base at Perekeshkul, three Armenian bases were also imaged in 2010. Only one of these, located at Nubarashen, on the outskirts of the Armenian capital of Yerevan, exhibited any signs of activity, though its significance is unclear. Several trucks were observed to move, and five objects that may have been artillery pieces disappeared between the two dates; however the resolution of the imagery was not sufficient to definitively identify these objects as weapons (Figure 29).

**Summary of findings**

Despite the lack of visible reinforcements at the border or along the line of contact, indirect evidence from imaging military bases suggests that modest resources may have been redeployed in response to the clashes. At two bases in Azerbaijan – Perekeshkul and Ganja – the number of artillery pieces was observed to decline in image pairs whose dates bracketed the events on the border. A similar phenomenon was observed at a base outside Yerevan in Armenia, however in that instance the identification of artillery was considerably more ambiguous. In addition to a decrease in artillery, a substantial increase in armored vehicles was noted at Perekeshkul. That facility, however, is a rear-echelon base located over 200 kilometers from the line of contact. An increase in the number of trucks and armored vehicles at the base is not an escalation in itself, and could also suggest a redeployment of forces away from the zone of conflict.

Ultimately, whether the changes observed at the various military bases represent operational redeployments cannot be determined with certainty; routine maintenance in the large covered garages directly adjacent to the weapons could also explain the variation in numbers, as could redeployments to or from other bases, or military exercises elsewhere. In the absence of imagery or reporting suggesting that the skirmishes had been accompanied by a redeployment of forces on either side, any such build-up on the border or the line of contact remains speculative.

**Conflict Resolution**

While it remains unresolved, the conflict between Armenia and Azerbaijan over Nagorno Karabakh has been stable for two decades. This stability is reflected in the relative lack of activity visible in the imagery. In all cases, direct imaging of the sites where skirmishes took place along the border and the line of contact failed to provide meaningful results; this outcome is consistent with the small scale of the reported violence. Less easy to explain is the lack of visible reinforcements on either side following the clashes. One possible explanation for this could be that such forces were indeed deployed, but were not visible due to camouflage or concealment. Alternatively, given the enduring and static nature of the conflict, it is possible that both sides were convinced that they had exploited their tactical situation to maximum advantage, and therefore deemed reinforcements unnecessary or not worth the potential for escalation.

**Early Warning Signs**

In the Armenia-Azerbaijan border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the movement of military equipment from bases; and
- the movement of logistics materiel and vehicles
Ukraine and Russia: 2014

Introduction
In early 2014, months of protest in the Ukrainian capital of Kiev culminated in the ouster of former president Viktor Yanukovich, and the emergence of pro-Russian protests in the southern Ukrainian region of Crimea. These quickly escalated on 27-28 February, when uniformed armed troops lacking identifying insignia seized Simferopol International Airport and a military airfield in Sevastopol. While the Russian government initially denied involvement in these events, the vehicles and military hardware associated with the unidentified armed groups led many observers to suspect that they were Russian troops acting as part of a coordinated military campaign — a deployment to which Russia admitted on 17 April 2014.

Following a referendum, the legitimacy of which was strongly questioned by international bodies including the Organization for Security and Cooperation in Europe (OSCE) and the European Union, Russia formally annexed Crimea on 18 March. Ten days later, US President Barack Obama expressed concern about the large numbers of Russian troops reported to be massing near Ukraine’s borders, and called on Moscow to de-escalate the tensions in the region. Russian president Vladimir Putin reportedly ordered a partial withdrawal of those troops on 31 March, although NATO reported that it had seen no evidence of a redeployment of forces. Tensions heightened further on 7 April, when pro-Russian groups occupied government buildings in the eastern Ukrainian cities of Donetsk, Luhansk, and Kharkiv, in a move that US Secretary of State John Kerry claimed was the result of paid agents provocateurs “determined to create chaos.” On 10 April, Supreme Headquarters Allied Powers Europe (SHAPE), the headquarters of one of NATO’s two military commands, released commercial satellite imagery depicting what it claimed was evidence of the Russian military buildup on Ukraine’s borders. Russian state media contested the validity of this imagery the same day, quoting an unnamed “senior official at the General Staff of the Russian Armed Forces,” who claimed that the images showed routine exercises which took place “in the summer of [2013]…including near the Ukrainian border.”

Motivations and Significance
The Ukrainian conflict is defined by the two diametrically opposed viewpoints held by its principal belligerents. Viewed from Kiev, the conflict stems from the Ukrainian people’s repudiation of Moscow’s influence, and from Russian irredentism. Moscow, on the other hand, views the conflict through the lens of a perceived obligation to protect russophones from what it has described as a neo-fascist seizure of power. The crisis is significant, as its eventual outcome has significant implications for the national identity and political orientation of Ukraine.

Due to the volatile situation, the high level of uncertainty related to events on the ground, and conflicting accounts being
FIGURE 30: Areas imaged in the Ukraine case study
FIGURE 31: Obstacles deployed at Belbek airbase. On 5 February 2014 (top left), the runway of Belbek airbase is unobstructed. By 10 March (top right), roadblocks have been constructed (red arrows), and MiG-29s have been placed across the runway (yellow arrows). Meanwhile, the nearby Russian airbase at Kacha (bottom) exhibits a rapid increase in the number of transport (yellow arrows) and attack helicopters (red arrows). Images ©2014, DigitalGlobe, NextView License | Analysis AAAS. Coordinates: Top: 44.69N, 33.58E, Bottom: 44.78 N, 33.55 E.
disseminated by the actors involved, AAAS conducted research on multiple locations in Russia and Ukraine using high-resolution satellite imagery acquired during the spring of 2014. These areas included the Crimean port of Sevastopol, along with known military installations in both Russia and Ukraine, particularly emphasizing those sites that were identified in media reporting as areas of conflict or of a buildup of offensive forces. Some images were also acquired by AAAS because they had been collected over the same area an unusual number of times during a short period that coincided with the crisis. In these cases, it was presumed the images had been targeted by other actors with an interest in the conflict, using information unavailable to AAAS. The goals of the research were to characterize accurately the situation on the ground; provide clarification regarding the controversy over the imagery released by NATO; and by so doing, identify features that could serve as warning signs should the crisis escalate into a broader armed conflict.

**Manifestations**

Prior to Crimea’s annexation, Belbek airbase, located 8km north of downtown Sevastopol, was a Ukrainian Air Force base hosting that country’s 204th Tactical Aviation Brigade, outfitted with the MiG-29 Fulcrum. During the crisis that preceded the referendum on annexation, the base was reportedly the site of a tense standoff between its personnel and pro-Russian forces. Analysis of satellite imagery reveals features that are consistent with these reports. The gates of the base, unobstructed on 5 February 2014, had been barricaded by roadblocks by 10 March. Elsewhere in the image, ten MiG-29s can be clearly identified, and are parked across the centerline of the runway at regular intervals in a configuration that appears designed to render the airstrip unusable by incoming aircraft (Figure 31). At the time, the pro-Russian forces were described by that country’s media as spontaneous “self-defense squads”.

In contrast to the defensive measures observed at Belbek, the Russian airbase at Kacha, located nine kilometers to the north, saw the arrival of numerous additional aircraft during the same interval (Figure 31). As the base of the Black Sea Fleet’s maritime patrol and surveillance aircraft, the units visible at the base prior to the crisis consisted primarily of Ka-27 “Helix” and Mi-14 “Haze” antisubmarine helicopters, as well as Be-12 “Mail” patrol aircraft. By 10 March 2014, however, these forces were augmented by the arrival of 17 additional helicopters, a level of activity that was not apparent in any imagery acquired from prior to the crisis. Although some of the new arrivals were of dimensions consistent with the Mi-14s based at Kacha, others were observed that more closely match Mi-24 “Hind” attack helicopters, which are not typically used in a naval role (Figure 31). Furthermore, the dimensions of the Mi-14 are nearly identical to those of the Mi-8 troop transport, from which it was derived. It is therefore possible that the aircraft that arrived at Kacha during the crisis were part of a combined force consisting of attack and troop transport helicopters. Further evidence in support of this hypothesis exists in the form of amateur video that appears to show a formation of Mi-24s and Mi-8s violating Crimean airspace during the opening hours of the crisis.

As both the base of operations for Russia’s Black Sea Fleet and a major commercial port, Sevastopol is a large regional center for maritime traffic. Similar to the trends observed on land, observations of vessels in Sevastopol’s many harbors and bays revealed trends consistent with a tightening of military control of the seas. At the entrance to Sevastopol Bay, for instance, the gap between the two breakwaters that separate the port of Sevastopol from the Black Sea itself was observed to be open to navigation on 14 July 2013. By 10 March 2014, however, and continuing through 18 March, the opening was controlled by
FIGURE 32: Obstructions to navigation at harbor entrances. Navigation into Sevastopol and Striletska Bays, open on 14 July 2013, has been restricted by the placement of nets or booms by 12 March, 2014. Images ©2014, DigitalGlobe, NextView License | Analysis AAAS. Coordinates: (top, Sevastopol Bay): 44.62N, 33.51E, (bottom, Striletska Bay): 44.61 N, 33.47 E.
a tugboat towing a floating chain or net attached to a new mooring buoy on the south side of the channel (Figure 32). The dimensions and superstructure configuration of this vessel are both consistent with those of an Okhtenskiy class seagoing tug, of which the Black Sea Fleet possesses seven, and whose color schemes match with that of the tug in question. During the same period, a similar obstacle was observed to have been erected at the entrance to Striletska Bay, located 2.5 kilometers to the west. Despite these controls, vessels of the Russian Navy were observed to have departed from their moorings and exited Sevastopol Bay. Noteworthy among this military traffic are two Ropucha class landing ships, each of which is capable of transporting up to 24 armored personnel carriers, and a Kashtan class mooring buoy tender that would be ideal for anchoring the ends of additional barricades of the type shown in Figure 32.98 Taken in sum, these observations strongly suggest that it was the Russian Navy that controlled the entrances to the harbors.

In a statement released on 9 April by the US ambassador to the OSCE, the regions surrounding the western Russian cities of Rostov, Belgorod, and Kilmovo were identified as the location of a Russian military buildup.99 If present, such forces would be located less than 40 kilometers from the Ukrainian border. Subsequent imagery released by NATO purported to show imagery of these forces on 26 March 2014, specifically Mi-8 and Mi-24 attack helicopters along with dozens of tanks and over one hundred infantry fighting vehicles and their associated logistics and support equipment.100 AAAS acquired imagery of these sites on numerous dates, including one scene from Belgorod on 26 March which appears identical to the image released by NATO on 10 April. The site, located on the outskirts of the city, appeared deserted on 10 November 2013 and 11 December 2013. By 22 March 2014, however, hundreds of vehicles were present, along with associated tents and materiel. Dozens more such vehicles arrived between 22 and 26 March (Figure 33), along with 21 helicopters whose dimensions match those of the Mi-8s and Mi-24s reported by NATO. Analysis of this imagery therefore corroborates NATO’s observations.

Summary of Findings
Satellite imagery analysis produced information that clarified the often-conflicting reports from the region. In the port city of Sevastopol, which houses the Russian Black Sea Fleet, a number of observations were made that can be considered warning signs of a potential armed conflict. These included the movement of combat and logistics vehicles, the construction of roadblocks, and the establishment of a maritime blockade of strategic ports and harbors. Particularly in the case of maritime actions, these observations suggest a level of coordination and organization consistent with the interpretation that the armed groups which seized control of Crimea in February-March 2014 were not solely “spontaneous self-defense militias.” The apparent use of Russian naval vessels to blockade the port of Sevastopol strongly suggests that such actions were at the very least supported by the Russian military. Alternate interpretations of these observations (e.g., routine troop movements) remain possible, particularly with respect to the deployment and disposition of land-based forces. When viewed in light of reports alleging the presence of Russian troops on the ground alongside irregular units,101 however, this analysis lends credibility to the involvement of Russian military forces in the takeover of Sevastopol.
FIGURE 33: Build-up of forces outside Belgorod. On 11 December 2013 (top), this military base on the outskirts of Belgorod is nearly deserted. By 22 March 2014 (middle), hundreds of combat and support vehicles are present. Four days later, on 26 March (bottom), further reinforcements have arrived. Images ©2014, DigitalGlobe, NextView License | Analysis AAAS. Coordinates: 50.65 N, 36.52 E.
Outside Sevastopol, imagery reveals patterns consistent with the involvement of Russian airborne units in the Crimean crisis. This is suggested by the type of and substantial increase in the number of helicopters present at Kacha airbase, along with clear signs that Ukrainian personnel at the neighboring Belbek airbase were sufficiently concerned about the prospect of an airborne assault to block the runway using their own aircraft. This anxiety may have been justified; observers have noted that Belbek’s runway would be ideal for landing heavy troop transports. Likewise, the barricades surrounding the base’s entrances appear to have been a well-advised – though ultimately unsuccessful – defensive measure; Belbek airbase was taken over in a Russian ground assault on 22 March. This outcome demonstrates that both of the features observed at Belbek (Figure 31) were unambiguous warning signs of future conflict.

Analysis of Russian forces inside Russia reveals that the country’s armed forces were engaged in large-scale military exercises at multiple locations in close proximity to the Ukrainian border. Multi-temporal observations of their encampments reveal units departing their staging areas, engaging in maneuvers, and returning to their encampments. These results substantiate NATO’s assertions of a troop buildup in the border regions. Indeed, in Belgorod, it was possible to watch additional reinforcements arrive over the course of four days from 22 to 26 March. During this same period, Russian state media ran headlines repeating Moscow’s declaration that there was “No troop build-up or undeclared military activity near Ukraine borders.” While the Russian government’s acknowledgement of the existence of ongoing military exercises may render the statement technically accurate with regard to undeclared military activity, the claim that no build-up was taking place is inconsistent with the observations of this investigation.

Conflict Resolution

As of this writing, the Ukrainian crisis has yet to reach a state that can be considered stable, let alone resolved. Formidable challenges are associated with obtaining reliable information from such a dynamic and politically charged atmosphere via traditional means. Satellite imagery, however, is able to circumvent censorship, intimidation, and selective reporting to produce an accurate, if limited, picture of the situation on the ground. As the conflict continues to evolve, such methods will continue to represent one of the most reliable means to—ascertain the truth about the situation on the ground.

Early Warning Signs

In the Ukraine-Russia border dispute, the key phenomena that were observed that could provide an early warning of impending conflict included:

- the blockading of Sevastopol by land and sea through road blocks and control of the harbor;
- the movement of Russian military equipment to Ukraine; and
- the movement of Russian military equipment to the border.
Due to their shared origins in the historically recent breakup of the Soviet Union, the conflicts associated with this region have more in common with one another than do many disputes elsewhere in the world. All three, for example, are driven at least partially by cross-border ethnic claims. Prior to its annexation, some 58% of the population of Crimea self-identified as ethnically Russian; a fact that Russian media and political leaders often emphasized in their rhetoric about the necessity of protecting “their” people from the alleged threat posed by the new government in Kiev. A similar situation existed in the NKAO prior to the breakup of the Soviet Union, where the 1989 census estimated the oblast’s population to be 75% Armenian. Prior to 2008, a significant population of ethnic Georgians also lived in South Ossetia, particularly in the Akhalgori district in eastern South Ossetia.

Closely related to cross-border ethnic claims, another driver for all three conflicts involves the desire to reclaim territory perceived as having been lost under unjust circumstances. In two of the three cases, this territorial claim involves historical borders which were established for political reasons. For example, during the Russian civil war, communist leaders had promised that Nagorno Karabakh would become part of Armenia, in order to rally that population to the Bolshevik cause. Following the establishment of the USSR, however, the oblast was instead incorporated into the Azerbaijani SSR, possibly as a strategy to ensure the hegemony of the Soviet Union over the national identities of its constituent republics. The dispute over Crimea also has its origins in Soviet politics. In 1954, at the initiative of Soviet leader Nikita Khrushchev, Crimea was transferred from the Russian Soviet Federative Socialist Republic (Russian SFSR) to the Ukrainian Soviet Socialist Republic (Ukrainian SSR). This move had few ramifications in the context of Soviet internal politics, however when Ukraine gained its independence, it resulted in the loss of Russian access to a territory that it had considered its own for hundreds of years.

Georgia was originally conquered by Russia in the early 19th century. Georgia never fully accepted Russian rule and briefly declared independence in 1918 after the Russian Revolution. In 1921, the Red Army reconquered Georgia and incorporated it into the Transcaucasian SFSR. In 1936, the TSFSR was broken up and Georgia became the Georgian SSR, with Abkhazia and South Ossetia operating as autonomous territories within it. It was the Georgian Supreme Soviet’s revocation of South Ossetia’s autonomy that led to the First South Ossetian War that lasted from 1991-1992.

While the similarities between these three post-Soviet conflicts are numerous, they remain distinct from one another in a number of critical ways. The most evident of these is scale. By almost all measures, Armenia, Azerbaijan, and Georgia are considerably smaller countries than Russia and Ukraine. The small but comparable sizes of Armenia and Azerbaijan have led to a protracted stalemate between the two countries, with no territory lost or gained for over two decades. In Georgia, by contrast, the imbalance of power resulted in massive losses within hours of the Russian intervention in South Ossetia. While Ukraine is far more evenly matched against Russia than Georgia was, the differential in military power is
Intra-Regional Comparison: Former Soviet Union

Still so severe that, faced with the Russian invasion of sovereign Ukrainian territory, the government chose not to fight at all.

In the two conflicts to which Russia was a party, this imbalance of power between actors was reflected in the results of the imagery analysis. Near the border with Ukraine, for example, large deployments of tanks, armored personnel carriers, infantry fighting vehicles, artillery, and logistics vehicles were observed in multiple staging areas. In Ukraine, no comparable deployments were apparent; imagery of Ukrainian military bases, such as Belbek airbase in Crimea, revealed only limited defensive measures. A similar imbalance was observed between naval forces at the port city of Sevastopol. Similarly, Georgian forces were significantly overmatched during the 2008 war. In total, Russia deployed over 25,000 soldiers, 1,000 pieces of armor or heavy artillery, 200 fixed wing aircraft, and 13 naval vessels in addition to over 10,000 militia soldiers from Abkhazia and South Ossetia. In contrast, Georgia deployed just over 10,000 troops over the course of the conflict. The appearance of both of these conflicts differs substantially from the dearth of activity observed in Armenia and Azerbaijan; the military resources of these former Soviet republics differ from those available to Russia by several orders of magnitude. Furthermore, the battle lines between the opposing sides in the southern Caucasus are static, while those separating Russian forces from the militaries of Georgia and Ukraine were highly fluid during the period of the conflicts in this study. The case of Armenia and Azerbaijan suggests that in addition to military and economic resources, the volatility of a conflict also plays a role in its observability using remote sensing.

Likewise, the three conflicts differ greatly in their chronology and the speed with which recent tensions have escalated. Ukraine, for example, transformed from a stalwart Russian ally to an adversary almost overnight. Compared to the “frozen” conflict that has defined the situation between Armenia and Azerbaijan for the past two decades, the annexation of Crimea and subsequent political crisis in eastern Ukraine happened nearly instantaneously. The interests of the actors involved also vary considerably across conflicts. While Armenia, Azerbaijan, and Georgia’s goals all center around holding or regaining territory, for Russia the territorial gains appear to be of secondary importance compared to its concerns about maintaining a geopolitical sphere of influence in its near-abroad. Finally, the degree of international engagement in the conflicts varies considerably. The crisis in Crimea and Ukraine has dominated both headlines and policy discussions around the world for months; coverage of the conflict between Georgia and South Ossetia, by contrast, had returned to nearly pre-crisis levels just one month after the Russian incursion, and the Armenian-Azerbaijani dispute is virtually unknown outside of specialist circles.
As illustrated by the intra-regional comparisons of conflicts in Africa, Asia, and the former Soviet Union, even border disputes that take place in the same region of the world can differ enormously in their scale, intensity, and physical manifestations. At first glance, this aspect of inter-state violence might make comparisons on a global scale appear impossible. While it is true that there is no single marker that defines all disputes, a number of themes can nevertheless be identified that arise in conflict zones throughout the world. In some cases, conflicts from separate regions have more in common with one another than they do with hostilities elsewhere in their own region; the reasons for this vary, but the examination of these shared elements may promote a better understanding of border conflict and the role that remote sensing can play in providing early warning of conflicts, and analyzing their evolution.

In three of the conflicts, (India-Pakistan, Georgia-Russia, and Ukraine-Russia), an existential threat to at least one party was present. In all of these conflicts, the scale of the military mobilization was substantial and easily documented through satellite imagery. Rear-echelon vehicle and artillery depots in both India and Pakistan were emptied of equipment as troops, logistics vehicles, and materiel were redeployed to the front line. In Georgia and Russia, the lack of timely imagery and short duration of the conflict hindered the observation of military assets. Despite this limitation, it was possible to observe equipment removed from Georgian bases, Russian tanks at the Roki Tunnel, and the Russian occupation of a Georgian military base.

In Ukraine, attack helicopters proliferated at Russian bases, while Ukrainian bases adopted improvised defensive measures. On the Russian side of the border, meanwhile, massive formations of tanks, artillery, and combat and logistics vehicles engaged in mobilization exercises were at such a scale that they dwarfed anything observed in any of the other conflicts studied. On the basis of these observations, it can reasonably be concluded that if a situation exists where a state could reasonably perceive an existential threat, imagery will likely detect the signs of a military mobilization.

The imaging strategy for detecting such a mobilization is of critical importance. In two of the three case studies just mentioned, attempts at directly imaging the border failed to locate significant signs of military escalation. In India and Pakistan, this was likely due to the combination of a limited imagery budget and the extremely long border between the two countries – factors that would only have been further frustrated by military units attempting to conceal their location. Similarly, no signs of escalation were observed in the images of the town of Agok, which straddles the border between South Sudan and Abyei. As in India and Pakistan, the long border between Sudan and South Sudan, combined with a small imagery budget reduced the utility of directly imaging the border. Attempts to image Russian troops along the border with Ukraine were successful, however this instance likely represents a special case, as the situation was sufficiently dire to attract the attention of military planners working at NATO headquarters in Belgium, who released annotated descriptions of the locations of Russian troops while the background research
for this report was being compiled. Without this guidance, which may have relied on classified information for its initial targeting, it is unlikely that any sign of the Russian buildup would have been visible. In all these instances, however, imagery acquired of known military bases revealed activity that suggested a deployment was taking place. When implementing an image acquisition strategy targeting military forces, therefore, it appears that concentrating on known bases or staging areas results in the highest likelihood of success.

The creation of new infrastructure preceded or accompanied the conflict in three instances, all of which took place in relatively remote or underdeveloped areas. Along the border between Eritrea and Djibouti, new roads were constructed leading from the Eritrean side of the border to the disputed area on Ras Doumeira; imagery revealed that these had been under construction several months prior to the outbreak of hostilities. Similarly in Sudan, the expansion of the airport in Talodi, and subsequent expansion of nearby fortifications, were clear signs of the escalating conflict. In Cambodia and Thailand, both countries constructed roads into contested territory, which may have increased the likelihood of skirmishes resulting from patrols encountering one another. These examples suggest that, if a potential conflict is suspected in a border area that is remote or otherwise inaccessible, the development of new transportation infrastructure is a possible leading indicator. Should such construction be followed by the movement of logistics vehicles, as was observed on the border between Sudan and South Sudan, and to a lesser degree, between Djibouti and Eritera, the likelihood of an impending conflict may further increase. Due to the numerous potential motivations for developing such infrastructure, such as transporting goods, however, such observations must always be considered in light of the geopolitical context.

Once a border dispute has escalated to the point that combat units are deployed in the field, they often engage in displays of force designed to provoke or intimidate the military and/or civilian leadership of the opposing side. In India, the deployment of the country’s most advanced air-superiority fighter, the Su-30MKI, to the border mere days after it had first achieved operational capability, was almost certainly calculated for maximum psychological effect against Pakistan. Similarly, during the dispute over Ras Doumeira, the small detachment of the Djibouti Armed Forces that directly confronted the Eritrean forces were supported by a far larger contingent of artillery and armor in the fortified positions that were visible to the south of the peninsula. While units never left undisputed Djiboutian territory, their superiority, both in number and firepower, could not have escaped notice by the Eritreans. As discussed above, a similar display of force, though on a far larger scale, took place in southwestern Russia during the Ukrainian crisis of 2014, with thousands of troops, tanks, and artillery pieces deployed in close proximity to the border with Ukraine. As such displays of force are explicitly designed to be noticed by the enemy, they are among the most easily recognizable warning signs of a possible outbreak of hostilities.
If a dispute escalates to the point of open warfare, damage to civilian structures becomes probable. This occurred in the case of Georgia – Russia, Sudan – South Sudan, and Cambodia – Thailand. In South Ossetia, hundreds of civilian structures were damaged by both Russian and Georgian troops. This occurred during the battle for Tskhinvali and later, after Georgia's withdrawal, ethnic Georgian villages were targeted for destruction. In the case of Cambodia – Thailand, damage was concentrated in the area around Preah Vihear. This included the destruction of the temple market as well as a small number of cluster munitions striking the nearby Thai village of Phrum Srol. In Sudan and South Sudan, targeting civilians has long been a feature of the conflict and was directly observed with imagery in both the towns of Abyei and Heglig. In the case of Cambodia and Thailand, this damage may have been largely inadvertent, while civilians were clearly targeted in the cases of Sudan – South Sudan and Georgia – Russia.

**Conclusion**

The origins of border conflict are variable. However, many themes, such as control over natural resources, territorial irredentism, and cross-border ethnic claims have surfaced multiple times in disputes that transcend national or regional boundaries. Similarly, the physical manifestations of these disputes, while constrained by the resources and geography of the belligerent countries, often share elements that have analogs elsewhere. While no single phenomenon documented in this report was present in all cases, the degree of overlap in the physical expression of this diverse set of conflicts was nevertheless substantial. Some phenomena, such as the movement of logistics equipment and displays of force, occurred at least once in every region under study, while others, such as the construction of new infrastructure, were observed exclusively in the developing world. Because of this variability, a potential investigator should always take care to tailor the imagery acquisition and analysis strategy to the situation at hand.

In instances where a contested boundary is located in a remote area, is shared between countries with less-developed transportation networks, or involves other natural barriers, the construction of new infrastructure that facilitates access to the disputed territory is a potential leading indicator of escalation. If such infrastructure already exists, however, focusing on transportation networks or the border itself is unlikely to provide advance warning without information about specific events or deployments that can be targeted. In the absence of such intelligence, imaging of military bases has proven to be a reliable proxy for detecting deployments. Other observations, such as aircraft deployments, can be useful in certain cases. However, their reliability as a warning sign for impending conflict is compromised by the fact that they are often stored inside hangars, where they are undetectable in satellite imagery.

Additional proxies for escalating conflict include naval deployments and defensive measures such as roadblocks and checkpoints. In low-intensity conflicts, such as the dispute between Armenia and Azerbaijan,
proxy measurements may be the only means available to measure a conflict. In areas where hostilities are intense and ongoing, more direct observations are possible. Due to the highly dynamic nature of these situations, however, frequent imaging may be necessary in order to ensure that important developments are captured. Finally, the data environment itself should be evaluated prior to formulating an analysis strategy. If little imagery of a situation is available, as is often the case due to spacecraft scheduling, budgetary, or licensing issues, a thorough analysis of all portions of each image should be conducted to ensure that nothing is missed and that the number of results per image is maximized. In some situations, however, the opposite situation prevails. In Ukraine, for example, an unprecedented quantity of imagery rendered the painstaking analysis of the entire study area impractical given the short time frame necessary to keep abreast of events. In situations such as these, a “triage” system should be implemented, in which the highest priority images, or portions of images, are analyzed first, while areas deemed less likely to contain useful information are de-prioritized. As the results of the analysis accumulate, these priorities should be constantly re-evaluated; if the initial analysis sites show little return, the weight given to the remaining areas should be adjusted accordingly. This process should then continue until sufficient data have been collected to form conclusions.

The results of this research have established that satellite imagery is frequently able to detect, quantify, and track a number of indicators that are often associated with an increased risk of armed conflict. The feasibility of using satellite imagery for this purpose varies according to the nature of the potential conflict, the availability of satellite imagery, and the budgetary and analysis resources available to the investigator. While it cannot be guaranteed that such analysis will produce actionable intelligence, the ability of satellite imagery to influence the international dialogue in a crisis situation is indisputable. This fact was re-affirmed when the accuracy of NATO’s satellite imagery of Russian military exercises near Ukraine, disputed by Kremlin-controlled media outlets, was corroborated during the course of this research.

By enabling organizations with relatively modest resources to engage in research whose impact can challenge the narratives produced by states involved in border conflict, satellite imagery can be considered a disruptive technology. Increased knowledge of this powerful tool, and how best to employ it, therefore has the potential to advance conflict-avoidance efforts on a global scale. To help achieve this, AAAS has produced a companion document to this report, the Border Conflict Analysis Module, which aims to build the capacity of organizations to best apply the techniques described here to their own areas of interest. It is expected that through these efforts, satellite imagery can contribute to increased transparency, heightened accountability, and ultimately, a more stable and peaceful world.
Endnotes


16 See note 9.


19 Economic and population estimates from CIA World Factbook.


