Geospatial Technologies and Human Rights Project

Satellite Imagery Analysis for Urban Conflict Documentation: Aleppo, Syria

September 2012
This report was produced by the Geospatial Technologies and Human Rights Project as part of the Scientific Responsibility, Human Rights and Law Program (SRHRL, http://srhrl.aaas.org) of the American Association for the Advancement of Science (AAAS). SRHRL brings scientists and scientific expertise to efforts to achieve human rights around the world. As a program of AAAS—the world's largest multidisciplinary scientific membership organization—SRHRL engages individual scientists and scientific associations in human rights efforts; applies scientific tools and technologies to enhance human rights work; brings human rights standards to the conduct of science; and promotes the human right to enjoy the benefits of scientific progress.

Acknowledgement
Primary support for this project was provided by the Oak Foundation through grant number OUSA-12-011.

Disclaimer
The interpretations and conclusions contained in this report are those of the authors and do not represent the views of the AAAS Board of Directors, its Council, and membership, or the Oak Foundation.

Contact
AAAS welcomes comments and questions regarding its work. Please send information, suggestions, and any comments to SRHRL at srhrl@aaas.org.
© Copyright 2012
American Association for the Advancement of Science
Science and Human Rights Program
1200 New York Avenue, NW
Washington, DC 20005 USA
Introduction

In August 2012, Amnesty International, USA (AIUSA) requested the assistance of the Geospatial Technologies and Human Rights Project of the American Association for the Advancement of Science (AAAS) to investigate the veracity and details of human rights-related reports stemming from the escalating conflict in Aleppo, Syria. Located in the northwestern area of the country (Figure One), Aleppo is Syria’s largest city and commercial hub, with a population of over two million people. On 15 July 2012, the International Committee of the Red Cross characterized the escalating conflict as a ‘civil war’, a designation that has since entered into common usage in media reporting. Since 19 July 2012, reports indicate that government and opposition forces have continued to clash both around and within the city. The conflict in Aleppo has led to accounts of heavy fighting, widespread shelling by tanks and artillery, and numerous civilian casualties.

Figure One: Overview

Map of Syria, Highlighting the location of Aleppo

1 http://www.bbc.co.uk/news/world-middle-east-18849362
Methods and Technology

Image Acquisition

Using information provided by AIUSA and media reports, imagery covering one hundred and eighty-two square kilometers of the city and its environs was acquired on the morning of 9 August by the Quickbird-2 satellite operated by DigitalGlobe, Inc. This acquisition coincided with reports of a major government effort to retake the neighborhood of Salaheddine in the southwestern quadrant of the city, which began the day prior. The second image, acquired by the GeoEye, Inc. satellite IKONOS on 23 August, was chosen to capture a variety of incidents that were reported to have occurred throughout the city during the intervening two weeks.

Table One: Imagery

<table>
<thead>
<tr>
<th>Date</th>
<th>Sensor</th>
<th>Image ID</th>
<th>Angle off-nadir</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 August 2012</td>
<td>QuickBird-2</td>
<td>101001000FF96D00</td>
<td>30.6º</td>
</tr>
<tr>
<td>23 August 2012</td>
<td>IKONOS</td>
<td>2012082308175390000011607379</td>
<td>18.3º</td>
</tr>
</tbody>
</table>

Figure Two: Neighborhood map of Aleppo, with locations of figures labeled

---

4 All images in this report, irrespective of source, are oriented north-up.
Image Analysis

Figure Two shows a map of Aleppo with the neighborhood locations of Figures Three through Fourteen identified. Due to its large size and high population density, Aleppo presented several unique challenges to image analysis and interpretation. The urban landscape of Aleppo is composed primarily of multi-story high-rise buildings in very close proximity to one another. Because of this, it was often difficult to see down to street level in the narrow spaces which separate one block from the next, especially when buildings were casting a shadow into that space (Figure Three). This situation was further exacerbated by the fact that the satellites’ operators had rolled the spacecraft away from a directly downward orientation in order to enable their cameras to capture the city of Aleppo as they passed over (see Table One for specific angles). While this image collection method resulted in timely imagery of the evolving conflict, it had the side-effect of introducing a horizontal component to the image, in which the vertical faces of structures appear to “lean over” adjacent open space as shown in Figure Three. When combined with the effects of shadows, this rendered large portions of the city invisible from above; in these areas, substantial events may have taken place that could not be detected. One indication that this may well have been the case was noted in the Salaheddine neighborhood, where smoke was noticed rising above an area whose density precluded an analysis of events occurring at street level. The nature of the buildings themselves may also make them more resistant than other structures to the type of structural collapse that would be obvious from above. While the fighting described in media reports would likely have produced clear damage in a city composed of less robust structures, this may not be the case for high-rises built from steel and reinforced concrete. Despite these analysis challenges, substantial amounts of destruction were observed in the city, as detailed below.

Figure Three: Effects of shadowing and elevation angle

Shadows and effects of imaging geometry frequently obscured streets. Image ©2012 DigitalGlobe, Inc.
Results

Reports of a government push to take control of the city on 8 August are consistent with observations such as the presence of tanks and armored vehicles on city streets (Figure Four), the destruction of a series of industrial buildings (Figure Five), which appear to have been actively burning when the image was acquired, and the widespread erection of improvised roadblocks and fortifications in neighborhoods throughout the city (Figure Six). Other observations which are congruent with reports of conflict include recently constructed revetments for small artillery pieces (Figure Seven), heavy vehicle tracks on roadways (Figure Eight), and a substantial increase in activity at a military base on the outskirts of the city (Figure Nine).

Figure Four: Armored vehicles on city streets

Armored vehicles, the dimensions and appearance of which match those of T-55 or T-72 tanks, were visible in multiple neighborhoods, including Ashrafiyeh (left) and Ard as-Sabbagh (Right). Image ©2012 DigitalGlobe, Inc.

Figure Five: Burning buildings
Smoke rises from a complex of industrial buildings in Ard as-Sabbagh district on 9 August. Image ©2012 DigitalGlobe, Inc.

Figure Six: Improvised roadblocks and fortifications

Makeshift defensive positions have proliferated in Aleppo. The yellow circles indicate roadblocks dismantled between 9 and 23 August, while the 102 red circles denote intact fortifications. Image ©2012 GeoEye, Inc.

Figure Seven: Newly erected revetments
These recently-constructed revetments—probable mortar positions—are visible near Aleppo airport on 9 August. Image ©2012 DigitalGlobe, Inc.

Figure Eight. Heavy vehicle tracks

Heavy vehicle tracks, the widths of which match those of T-55 or T-72 tanks, are present on city streets. This observation is consistent with reports of armored vehicle movements in the city. Image ©2012 DigitalGlobe, Inc.

Figure Nine. Activity at military base

Armor and logistics vehicles crowd a once-empty lot at a military base on the outskirts of Aleppo. Images ©2012 DigitalGlobe, Inc; Left image acquired 5 October 2011, courtesy of Google Earth.

Between 8 and 23 August, reports indicate that heavy fighting took place in Aleppo, particularly the Salaheddine neighborhood. An analysis of imagery acquired on the morning of...
23 August supports these reports. Many streets around the city have become littered with debris, and the asphalt is blackened in many areas in a manner that resembles scorch marks from fire and explosions. Probable shell craters and debris patterns consistent with artillery projectiles are also evident both in Salaheddine and elsewhere (Figure Ten). Damage was also noted to structures. On 9 August, for example, a probable armored vehicle was sighted in Ard as-Sabbagh district; by 23 August the vehicle had disappeared, and most of a nearby building had been destroyed (Figure Eleven). In the northern district of Ayn at-Tal, 84 makeshift structures appear to have been burned in the parking lot of an industrial facility, scorch marks are visible on buildings, and craters have appeared in the streets (Figure Twelve). In total, 117 instances of damage to buildings and infrastructure were observed in the imagery between 9 and 23 August.

Figure Ten. Evidence of shelling

On 9 August (left), no damage is visible at Hnano Military Base (top left) and a vehicle depot (bottom left). By 23 August, however, markings consistent with exploding shells have appeared in the barracks courtyard (top right),
while the road has been blackened by a probable artillery impact (bottom right). Left images ©2012 DigitalGlobe, Inc.; right images ©2012 GeoEye, Inc.

Figure Eleven. Urban combat in Ard as-Sabbagh district

On 9 August (top), little damage is visible, though a probable armored vehicle is present in the intersection at the northwest corner of the park. By 23 August, that
intersection has been blackened as if by a firefight, and the L-shaped building at the corner of the park has been partially demolished. Top image ©2012 DigitalGlobe, Inc.; bottom image ©2012 GeoEye, Inc.

Figure Twelve. Craters and destruction of temporary structures

On 9 August (top), large numbers of temporary structures are present near a roundabout in Ayn at-Tal district. By 23 August (bottom), however, 84 of them have been replaced by marks consistent with burning (yellow arrows). Scorch marks are also present on the roofs of nearby buildings (red arrows), and
probable craters have formed in the streets (green arrows). Top image ©2012 DigitalGlobe, Inc.; bottom image ©2012 GeoEye, Inc.

Figure Thirteen. Changes in position of probable attack helicopters

At a military apron at Aleppo International Airport, two helicopters the dimensions and rotor configuration of which match that of the Mi-24 “Hind” (indicated by yellow arrows) have moved between 9 August (top) and 23 August (bottom). This aligns with reports of the use of such assets against opposition forces. Top image ©2012 DigitalGlobe, Inc.; bottom image ©2012 GeoEye, Inc.

Movements of military vehicles consistent with reports of operational deployments were also observed. Between 9 and 23 August, for example, at Aleppo international airport, two aircraft the dimensions of which match those of Mi-24 attack helicopters,⁶ have changed locations,

---

suggesting recent flight (Figure Thirteen). This aligns with reports that the Assad regime has been employing helicopter gunships against the opposition. Meanwhile, on 9 August at a military vehicle depot, over 35 heavy trucks towing trailers resembling the ChMZAP-5523 multi-purpose military vehicle trailer are visible at an army depot. By 23 August, they have all departed the area (Figure Fourteen).

Figure Fourteen. Activity at military vehicle depot

On 9 August (left), dozens of heavy trucks and vehicle trailers are present; on 23 August (right) all have departed, suggesting large-scale military activity. Left image ©2012 DigitalGlobe, Inc.; right image ©2012 GeoEye, Inc.

Conclusion

The analysis conducted by the Geospatial Technologies and Human Rights Project contained in this report documents a two-week period of the conflict in and around the city of Aleppo. Despite the difficulties associated with image analysis in such a densely-populated urban environment, multiple pieces of evidence were observed that largely corroborate accounts of intense fighting and street battles within the city. Major findings of this report include the documentation of over one hundred instances of damage to buildings and infrastructure, the erection of a similar number of improvised roadblocks, numerous shell craters, and the deployment of heavy armored vehicles in civilian neighborhoods. Given the large swaths of the city where visual analysis was ineffective, however, the findings presented here only place a lower limit on the degree of destruction in the city of Aleppo. If fighting has also taken place in the narrow streets adjacent to the wide boulevards where its effects are visible from above, then the actual level of damage would likely be higher than that documented in this report.

---