Commercial Remote Sensing Satellites and the Regulation of Violence in Areas of Limited Statehood

Steven Livingston

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Commercial Remote Sensing Satellites and the Regulation of Violence in Areas of Limited Statehood

Abstract
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Disciplines
Communication Technology and New Media | International and Intercultural Communication

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The ICTs, Statebuilding, and Peacebuilding in Eastern Africa Project:

This occasional paper series is part of a larger project run by the Center for Global Communication Studies (CGCS) at the University of Pennsylvania, conducted in partnership with the Programme in Comparative Media Law and Policy (PCMLP) at University of Oxford, and funded by the Carnegie Corporation of New York (CCNY). This project seeks to bring greater clarity about the expectations and the realities of the use of communication technologies in developing contexts. In media and development theory, policy, and practice, strong normative statements about the transformative power of ICTs have often clouded the understanding of how people and communities actually make sense of, and engage with, the old and new communication technologies that surround them. Under this framework, this two-year project explores the use of ICTs in Eastern Africa.

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## Contents

Introduction.......................................................................................................................................................... 5

Digitally Enabled Collective Action in Areas of Limited Statehood ................................................................. 6

Remote Sensing Satellites .................................................................................................................................. 10

The Emergence of a Commercial Remote Sensing Sector .............................................................................. 13

Remote Sensing and the Regulation of Violence .............................................................................................. 18
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Introduction

It is difficult for some to recall a world without digital maps, satellite images, and nearly ubiquitous navigation devices. Yet when high-resolution remote sensing satellites were available to only the world’s most powerful and technically sophisticated states, access to precision satellite images was tightly controlled, and those who violated the restrictions were subject to severe penalties. In 1985, for instance, Samuel Loring Morison, an American naval intelligence analyst, was convicted on two counts of espionage and two counts of theft of government property for leaking satellite images of a Soviet shipyard to Jane’s Defense Weekly, a respected defense analysis publication.1 Figure 1 shows one of the KH-11 reconnaissance satellite images leaked by Morison.

Figure 2 is the same shipyard as it appeared in an image taken by a European commercial satellite and used by Google in 2014. One is now free to inspect what was Soviet Shipyard 444 (Nikolayev South Shipyard, Mykolaiiv, Ukraine) using Google Earth.2 These two images illustrate the extraordinary changes in remote sensing that have occurred since 2000, the year the first high-resolution, commercially owned and operated satellite images became available. Images that were once shrouded in state secrecy are now available to anyone possessing a computer and internet connection, sometimes even at no cost. This paper considers the implications of this development for governance in areas of limited statehood.

I begin with an overview of two key concepts: areas of limited statehood and digitally enabled collective action. The paper then reviews remote sensing and geographical information systems (GIS) technology. Given the technical complexity of the topic and limited space, the goals of this paper must remain modest. The aim is to offer an overview of major developments and outline some of the technical capabilities of various satellites. Two key points emerge in this second section of the paper.

First, remote sensing is no longer monopolized by powerful states, though many of the most powerful and capable satellites are owned and operated by corporations with close ties to the defense industries of major military and technological powers. Despite these ties, a robust international commercial sector offers remote sensing products to nonstate actors and to other states that lack the resources needed to launch and operate surveillance satellites.

Secondly, remote sensing data are multifaceted. Commercial satellites offer information that goes well beyond pictures from space. Data about precise spatial relations and coordinates are available, as are multispectral and hyperspectral data that register the material composition of objects on the ground.

A third section of the paper offers a brief discussion of the political implications of these technological developments for a particular expression of limited statehood: the unaccountable and excessive use of force by weak state security forces. I am interested in the use of commercial remote sensing in the “regulation of violence” by nonstate actors in the context of the Margaret E. Keck and Kathryn Sikkink model of transnational advocacy.3 As they note, “The ability to generate and use information strategically is the main asset of transnational advocacy networks.”4 Commercial remote sensing satellite technology has affected that ability, perhaps profoundly.

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2 A higher resolution image is available with Google Earth, but for the purposes of comparison this less precise image was used. It was found in less than five minutes of scanning the waterfront of the Port of Mykolaiiv. Using the toggles on Google Earth, one can move over a continuous image of the entire planet.

Figure 1

Figure 2
Source: Google Earth Engine with “Mykolaiv” as the search term
Digitally Enabled Collective Action in Areas of Limited Statehood

In its broadest terms this paper explores digitally enabled collective action in areas of limited statehood. An area of limited statehood is a place, policy arena, or period of time when the governance capacity of the state is unrealized or faltering. Governance can be defined as initiatives intended to provide public goods and to create and enforce binding rules. In its broadest terms this paper explores digitally enabled collective action in areas of limited statehood. In its broadest terms this paper explores digitally enabled collective action in areas of limited statehood. Governance can be defined as initiatives intended to provide public goods and to create and enforce binding rules. International affairs literature also refers to steering and social coordination when speaking of governance. I treat governance as an analog to collective action, a term more common to political economics.

Public goods include individual and collective security, economic welfare, education, public health, infrastructure, and a clean and safe environment. Binding rules may come in the form of codified law that is enforced by formal state institutions (security forces and judiciary), or they may be norms and customs that are enforced by social pressure and informal organizations, such as community policing and traditional forms of arbitration and justice.

A state’s governance capacity may fall short in several ways. Where a state’s governance incapacity is coterminous with its sovereign borders, it can be said to be a failed state. In 2014, Central African Republic offered one example of total state failure. Other examples would include states that have limited governance capacity in locations that are distant from central administrative resources, as in the Democratic Republic of Congo. North and South Kivu in the DRC are too inaccessible for the state administrative apparatus in Kinshasa to have a meaningful impact. Limited statehood is also evident in urban slums such as Makoko in Lagos, Nigeria or Mathare in Nairobi, Kenya. These are places devoid of state provisioning of roads, sanitation, security, and most other public goods, despite their proximity to central administrative resources. Yet in both cases, the state cannot—or will not—provide public goods or enforce binding rules with legitimate force.

Limited statehood may also apply to a particular policy arena. In this case, the state fails to provide a particular public good, such as adequate healthcare or effective and accountable security. This condition may apply to a particular location, such as an urban slum or distant region, or it may be coterminous with state borders. Limited statehood may also be sociologically based, as is the case when an otherwise consolidated state fails (again, sometimes by design) to provide public goods to persons according to their race, gender, or religion, to name a few of the common bases for discrimination. Apartheid South Africa offers an example of such a state. The governance capacity of a consolidated state such as this is oriented toward the control of a disaffected and disenfranchised segment of the population. Security comes to be defined as securing one part of the population from demands made by another marginalized segment of the population. Finally, state governance capacity may be disrupted, such as when a natural disaster degrades the governance capacity of a state in the affected region. The scope of the diminished governance capacity of the state and its duration is contingent on its capacity prior to the catastrophe.

In general, rather than a dichotomous variable, as references to failed (or not) states imply, state governance capacity is more accurately conceptualized as running along a continuum: from failed states at one end to fully consolidated states at the other. It is also multifaceted, evident in geographical pockets of territory or contingently absent according to sociological considerations or temporary exigencies. This makes meaningful metrics of state governance capacity highly problematic. What might appear to be a fully consolidated state according to gross indicators might in fact be a quite limited state according to sectorial, social, or even spatial grounds. Indeed, it is

5 Steven Livingston and Gregor Walter-Drop, Bits and Atoms: Information and Communication Technology in Areas of Limited Statehood, (New York: Oxford University Press, 2014)
intuitively clear that limited statehood of one sort or another is quite common. This is true even of the Global North, where large urban slums constitute, at least to a degree, an area of limited statehood. According to Thomas Risse, as much as 80 percent of the world’s population is affected, in one way or another, by an area of limited statehood.8

Thinking in terms of areas of limited statehood also disentangles governance from government (or the state). This is especially important to the discussion of remote sensing satellites and their role in mitigating some of the harsher effects of limited statehood. While states are limited in the ways previously described, it does not, perforce, follow that governance is altogether missing. Governance might instead come from alternative sources. Nongovernmental organizations (NGOs), international NGOs (INGOs), civil society organizations, clans, and even gangs may serve, in varying places, moments, and to varying degrees of effectiveness, as alternative governance modalities. Most often, governance is provided by a mix of modalities, such as public/private partnerships for public service provisioning in mostly consolidated states, or INGO, NGO, and international lending agency collaboration in healthcare in areas with little or no state capacity.9

Multimodal governance is particularly important when considering the role of technology as a sort of governance force multiplier. Leveraging technology lowers the organizational burden historically associated with the provisioning of public goods.10 By lowering communication and collaboration costs, information and communication technology facilitates organizing without formal organizations, such as states. Hierarchically organized bureaucratic structures are, in essence, communication devices, facilitating flows of information and decisions up and down a command and control organizational structure. The state is the ultimate expression of this particular governance morphology. Recent scholarship has considered the role of digital technology in the provisioning of public goods, even in the absence of formal hierarchical state institutions. Community groups, NGOs, INGOs, and states facing shortages in administrative resources can leverage mobile telephony, digital maps, and text-messaging aggregating systems such as FrontlineSMS to strive for goals that would otherwise be unattainable.11 The main benefit derived from the proliferation of these technologies is the reduced communication and collaboration costs associated with networked information environments. Rather than building organizations to achieve a public good, digital technologies are used to organize collective actions intended to provide a public good, even in the absence of the state. It involves a shift from a noun (organizations) to a verb (organizing).

This study focuses on a second possible effect on governance associated with the proliferation of digital technology. Whereas digitally enabled collective action centers on the use of digital technology in the provisioning of public goods in areas of limited statehood, this paper concerns itself with the use of digital technology in attempts to strengthen accountability for the maladroit and indiscreet transgressions of broadly recognized international norms. Stated more precisely, this paper seeks to understand how remote sensing might strengthen efforts to hold those responsible for egregious acts of violence against civilian populations to greater account.

Several examples of technologically enabled surveillance of abuses illustrate this point. Mobile phone cameras are now nearly ubiquitous. Among other outcomes, their proliferation has led to a greater awareness of police misconduct.12 In 2014, when the New York City Police Department (NYPD) asked citizens to tweet pictures of positive encounters with the NYPD it was instead inundated by pictures of police violence directed against

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8 Thomas Risse 2011, p. 6.
citizens. In 2014, following several deadly confrontations with citizens across the United States, there were broad calls for police departments to adopt the use of cameras as standard equipment for every police officer. In these cases, relatively responsive state institutions took steps to correct maladroit policing practices.

Crowdsourced election monitoring also relies on ubiquitous mobile phones and digital maps. Intuitively, greater public confidence in the integrity of an election diminishes the likelihood of the sort of post-election violence seen in Kenya in December 2007 and January 2008. Crowdsourced mapping—or crisis mapping—is now used around the world.

Another example of digitally enabled transparency is found in DNA matching. Like so many aspects of modern life, advances in genetics have come hard on the heels of advances in computer processing power and speed. Forensic anthropologists have taken advantage of the lower costs and increased speed of genetic analysis to match the DNA of victims of massacres with surviving members of an affected community. From these data criminal cases are built against the perpetrators of the violence.

We are interested here in exploring the connection between digital technologies and abuses by security forces in places where the state is less responsive, either because of administrative incapacity, indifference, or deliberate practice. Inquiries are limited to remote sensing satellite images and geospatial data and their use by transnational advocacy networks. This narrowed focus excludes other research questions relating to digital technologies and governance, along with some questions relating to remote sensing alone and governance. A complete list of these projects would itself constitute a separate paper.

The balance of this study will consider the role of remote sensing and GIS in governance where the state is only partially consolidated. Particular focus is given to cases in which the state has the administrative or logistical capacity to deploy force to most or all regions found within its sovereign borders, while lacking the capacity to impose discipline to prevent maladroit application of force against civilian populations, often in violation of broadly recognized international norms. An alternative circumstance is found when the capacity to impose discipline exists in the absence of will. Indeed, indiscriminate violence is the goal, either for purposes of revenge or intimidation or other unfathomable reasons. Applied in such cases, the use of force erodes the legitimacy of the state. Max Weber’s definition of statehood is important to this framing of the question. His definition of statehood involves the legitimate application of violence for the purpose of enforcing binding rules.

(W)e have to say that a state is a human community that (successfully) claims the monopoly of the legitimate use of physical force within a given territory…Specifically, at the present time, the right to use physical force is ascribed to other institutions or to individuals only to the extent to which the state permits it. The state is considered the sole source of the ‘right’ to use violence.

Poorly applied, the state’s use of force undermines legitimacy. One of the examples offered below involves the use of remote sensing satellite imagery to uncover abuses by poorly trained and undisciplined Nigerian soldiers as...
they confronted Boko Haram, the Islamist insurgency group.\textsuperscript{22} There is no question that Boko Haram is a security threat to the people of Nigeria. Yet the Nigerian security forces are themselves a separate threat to individual and collective security. How might remote sensing help address this condition? The next section begins an answer to this question by way of a description of the evolution of remote sensing technology.

Remote Sensing Satellites

Reconnaissance satellites have been in use for over a half-century, starting with the launch of the American Corona reconnaissance satellite in 1959 and the Soviet Zenit satellite in July 1962. Several versions of the Zenit satellite continued to be launched as late as 1994. Other more recent Soviet/Russian satellites include the Resurs and Persona series, with the latter also known as Kvarts (Quartz). The next generation American satellite system was the KH-11 KENNAN, renamed CRYSTAL in 1982 and more recently dubbed the Evolved Enhanced CRYSTAL (EEC). The later versions of the satellite are also classified as KH-12, Advanced KENNAN, or Improved Crystal. The original KENNAN was the first to employ Electro-optical sensors and a charge-coupled device, allowing the film capture system–involving the retrieval of a film canister–to be replaced by data transmissions to earth.

Aside from the American and Russian government programs, starting in the 1980s the Chinese government developed film-return satellites, and in the 21st century programs, starting in the 1980s the Chinese government

with a similar 2.4-meter reflective mirror producing a six-inch spatial resolution. This means the satellite is capable of distinguishing objects on the ground that are no larger than six inches in diameter, or so it is speculated.

Some features of these powerful surveillance satellites are hard to keep secret. The low-earth orbit and size of the government satellites make them fairly easy to spot, a fact that has created a hobby: satellite tracking. Amateur satellite trackers around the world use telescopes and the Internet to collaboratively track the orbital path of various satellites. On August 28, 2013, a Delta-IV rocket, the most powerful in the U.S. inventory, capable of putting a twenty-five ton payload into low Earth orbit, was used to launch a National Reconnaissance Office satellite from Vandenberg Air Force Base in California. Amateur satellite trackers spotted the satellite on its very first orbit. They were able to calculate its orbital parameters from information gleaned from observing the satellite as it arced across the sky.

From there, calculating an orbit of 252 by 996-Kilometer at an inclination of 97.88 degrees, hobbyists were able to deduce that it was, as originally suspected, a KH-11, and that its mission was to complete a specific constellation of surveillance satellites. Knowing the orbit of other KH-11s led to the determination of the purpose of NROL-65 within its first orbit. As evidenced, much can be deduced about a satellite by its launch, orbit, and relationship to other satellites in orbit.

Yet other aspects of government satellites are not well known. This includes the nature and capabilities of the sensors or cameras carried onboard. That is not true, of course, for the commercial remote sensing industry. Before describing several civilian and quasi-civilian satellite systems it is appropriate to discuss some of the features and capabilities of the hardware onboard commercial satellites. The principal objective of this section is to

References:


29 The launch can be viewed on YouTube. https://www.youtube.com/watch?v=gL1dEBZ6Vyc
illustrate capabilities without delving into an overburdened discussion of the inventory of satellites and sensors.

Three important metrics are associated with remote sensing satellites: spatial resolution, spectral resolution, and temporal resolution. Spatial resolution refers to the detail that is discernible in an image or, put another way, the size of the smallest possible feature that can be detected in an image. Figure 3 offers three contrasting images of the same location. Moving from left to right, one sees an example of a ten-meter resolution image, a thirty-meter resolution, and, finally, an eighty-meter resolution image. The ten-meter resolution image obviously offers the greatest detail of the three images, yet it should be kept in mind that ten meter resolution imaging is not representative of the most capable high-resolution sensors. As we will see in our review of several civilian or quasi-civilian satellite systems, most now offer sub-one-meter resolution images, with one offering thirty-one-centimeter (about 12 inches) images. That means that from about 400 miles in space, high-resolution sensors can take pictures that are detailed enough to see objects on the ground that are about the size of a small microwave oven. As a point of comparison, we noted above that a KH-11 satellite might have a spatial resolution as great as 6 inches.

A second metric is the spectral resolution of a sensor. This refers to the number of bands of the electromagnetic spectrum that a sensor is capable of detecting.

Electromagnetic radiation can be described as a stream of photons moving at the speed of light in a wave-like pattern. Visible light falls between infrared and ultra violet and constitutes only a tiny fraction of energy. Radio waves, microwaves, infrared waves, ultraviolet waves X-rays and gamma rays make up the rest of the electromagnetic spectrum. Spectral resolution is measured in terms of bands, though it is important to keep in mind that there are no truly fixed points of separation between bands. High or hyper-spectral resolution involves 220 bands; medium or multi-spectral resolution collects data in 3 - 15 bands; and low spectral resolution collects data in 3 bands. A single band image is generally displayed as shades of gray.

Spectroscopy or spectrography refers to the measurement of radiation intensity as a function of wavelength in relation to matter. Put metaphorically, it can see differences in matter. Multispectral and hyper-spectral sensors and processing systems are used in astronomy, agriculture, biomedical imaging, mineralogy, physics, and surveillance. Physical matter and gases leave unique ‘fingerprints’ according to

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33 These are the three key metrics for assessing satellite capabilities used in this study. Others metrics not discussed here would include onboard data storage capacity, geolocation accuracy, daily coverage total, swath width, and camera agility, including the ability to take stereo images on the same pass. Stereo images (two or more images taken of the same spot but from different angles) offer the possibility of creating 3-dimensional extractions or models of the imaged location. These attributes are discussed at length on various online reviews.
the energy they emit in relation to the electromagnetic spectrum. Known as spectral signatures, they allow scientists to identify the materials found in a scanned object. For example, fat, water, and protein contents in industrial scale meat batches are determined by near infrared (NIR) reflectance spectroscopy.\textsuperscript{34} Another example is that of spectral signatures, which help mineralogists find untapped oil deposits and enologists map grape varieties growing in a particular region.\textsuperscript{35} The health of a forest (determined by measuring photosynthesis), the chemical composition of smokestack plumes, or the material composition of waste products either in the water or on the ground is detectable from space. In short, “seeing” involves much more data than is typically associated in popular imagination with satellite images.

There are trade-offs between spatial resolution and spectral resolution. High spatial resolution is associated with a low spectral resolution. The more detailed the spatial resolution, the more likely the image will be panchromatic (gray-scale). This pattern in the satellite systems is summarized in Tables 1 and 2.

The final metric of interest to this paper is temporal resolution, which refers to the frequency of flyovers of the same location by a satellite or constellation of satellites. This is also commonly referred to as revisit frequency. Intelligence agencies -- and now NGOs and advocacy organizations -- use repeated coverage of the same location to reveal changes in infrastructure or naturally occurring features.\textsuperscript{36} Deforestation, receding glaciers, rising oceans, weapons facilities, troop deployments, construction sites, and soil disruption (where mass graves might be situated) are monitored over time from orbit.

Yet images of whatever type and scale are not the most important product of remote sensing satellites. The ability to scientifically measure physical space adds to the

\textbf{Figure 4}
Source: http://www.cyberphysics.co.uk/topics/light/emspect.htm

\textsuperscript{36} Sean Aday and Steven Livingston, “NGOs as Intelligence Agencies: The Empowerment of Transnational Advocacy Networks and the Media by Commercial Remote Sensing in the Case of Iranian the Nuclear Program,” *Geoforum, 40* (2009) 514-522.
importance of remote sensing. The geodetic location of a topographical feature on, in, or above the Earth is calculated according to its longitude, latitude, and its vertical distance from the center of the Earth. Determination of geodetic location is now assisted by the specification of every inch of the planet's surface and the creation of technologies that allow for geospatial awareness, that is, the constant update of awareness of where in space anything is temporally situated.

Geographical information systems (GIS) are software platforms used to manage and process geospatial data. With GIS and a handheld instrument able to interact with geographical positioning satellites (GPS), or other devices such as mobile phones that achieve a similar effect through triangulation with cell towers (that are themselves situated in precisely known coordinates), one can situate any object or phenomena in physical space on a digital map. These are the technical attributes that make “smart bombs” smart, capable of striking targets thousands of miles away by following GPS signals in relation to a set of coordinates. The same attributes allow commuters to find a particular destination. Another important feature of GIS and remote sensing geospatial data is the ability to array data about events and phenomena in physical space. By putting a pin on a digital map, usually referred to as dropping a waypoint, one can specify the location of an event or abstract phenomena. Patterns and associations are revealed in the process.


The Emergence of a Commercial Remote Sensing Sector

How has the commercial remote sensing industry emerged? Part of the story involves the evolution of Landsat. Landsat was one of the first remote sensing satellite systems to transition from a state ownership and operation system to the private sector. In 1979, President Jimmy Carter authorized the transfer of Landsat operations from NASA to the National Oceanic and Atmospheric Association (NOAA). Carter’s order also signaled the eventual privatization of Landsat. This occurred six years later, when the Earth Observation Satellite Company (EOSAT), a jointly owned company by RCA and Hughes Aircraft, assumed control of the operation. At time of this writing, there have been eight Landsat satellites in all (one of which failed), and two operational Landsat satellites in orbit in 2014.

Strict references to commercial or private satellites, as opposed to state-owned satellites, are difficult. “Private” and “commercial” have different definitions in different nation-states. In Europe, references to commercial satellites connote the ability to generate revenue, regardless of ownership of the satellite. In the U.S., the term “commercial” is applied to private sector satellites. Despite the differences, “commercial” satellites share the common characteristic of offering images and other data for sale on an open market. In the case of American commercial satellites, this capability is the result of the Land Remote Sensing Policy Act of 1992. The Act declared the United States’ support of “continuous collection and utilization of land remote sensing data from space” in the belief that such data are of “major benefit in studying and understanding human impacts on the global environment, in managing the Earth’s natural resources, in carrying out national Security functions, and in planning and conducting many other activities of scientific, economic, and social importance.” To this end, it established procedures for licensing private remote sensing companies.

In 1994, Lockheed was granted one of the first licenses from the U.S. Department of Commerce for commercial satellite high-resolution imagery. In October 1995, Space Imaging, a partnering company with Lockheed, launched the Ikonos satellite in September 1999. On January 1, 2000, Ikonos’ 1-meter panchromatic and 4-meter multispectral imagery went on the market. It was the world’s first commercial, high-resolution remote sensing satellite. Hundreds more satellites have followed.
### Table 1
Source: Landsat—A Global Land-Imaging Mission, United States Geological Survey

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Launch</th>
<th>Decommissioned</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat 1</td>
<td>July 23, 1972</td>
<td>January 6, 1978</td>
<td>MSS/RBV</td>
</tr>
<tr>
<td>Landsat 2</td>
<td>January 22, 1975</td>
<td>July 27, 1983</td>
<td>MSS/RBV</td>
</tr>
<tr>
<td>Landsat 3</td>
<td>March 5, 1978</td>
<td>September 7, 1983</td>
<td>MSS/RBV</td>
</tr>
<tr>
<td>Landsat 4</td>
<td>July 16, 1982</td>
<td>June 15, 2001</td>
<td>MSS/TM</td>
</tr>
<tr>
<td>Landsat 5</td>
<td>March 1, 1984</td>
<td>2013</td>
<td>MSS/TM</td>
</tr>
<tr>
<td>Landsat 6</td>
<td>October 5, 1993</td>
<td>Failed</td>
<td>ETM</td>
</tr>
<tr>
<td>Landsat 7</td>
<td>April 15, 1999</td>
<td>Operational</td>
<td>ETM+</td>
</tr>
<tr>
<td>Landsat 8</td>
<td>February 11, 2013</td>
<td>Operational</td>
<td>OLI/TIRS</td>
</tr>
</tbody>
</table>

### Table 2
Several examples of Satellites Offering Data on the International Market
Source: Assembled by Author

<table>
<thead>
<tr>
<th>Name</th>
<th>Launch Date</th>
<th>Spatial Resolution</th>
<th>Temporal Resolution</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADARSAT-1</td>
<td>November 4, 1995</td>
<td>Variable&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24 days</td>
<td>Canada</td>
</tr>
<tr>
<td>IRS-1C</td>
<td>December 28, 1995</td>
<td>6 meter panchromatic</td>
<td>24 days</td>
<td>India</td>
</tr>
<tr>
<td>EarlyBird-1</td>
<td>December 24, 1997</td>
<td>3 meter panchromatic</td>
<td>N/A</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 meter multispectral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ikonos</td>
<td>September 24, 1999</td>
<td>82 cm panchromatic</td>
<td>3 days</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 meter multispectral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EROS-A</td>
<td>December 5, 2000</td>
<td>1.8 meter</td>
<td>N/A</td>
<td>Israel</td>
</tr>
<tr>
<td>QuickBird</td>
<td>October 18, 2001</td>
<td>60 cm panchromatic</td>
<td>1 – 3.5 days</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4 meter multispectral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spot 5</td>
<td>May 4, 2002</td>
<td>5 meter panchromatic</td>
<td>2 – 3 days</td>
<td>France</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 meter multispectral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OrbView-3</td>
<td>June 2003</td>
<td>1 meter panchromatic</td>
<td>&lt; 3 days</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 meter multispectral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carosat-1</td>
<td>May 5, 2005</td>
<td>2.5 meter panchromatic</td>
<td>5 days</td>
<td>India</td>
</tr>
<tr>
<td>EROS-B</td>
<td>April 25, 2006</td>
<td>70 cm</td>
<td>N/A</td>
<td>Israel</td>
</tr>
<tr>
<td>Cartosat-2</td>
<td>January 10, 2007</td>
<td>&lt; 1 meter</td>
<td>4 days</td>
<td>India</td>
</tr>
<tr>
<td>CosmoSkyMed-1</td>
<td>June 8, 2007</td>
<td>SAR&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Few hours in constellation</td>
<td>Italy</td>
</tr>
<tr>
<td>TerraSar-X</td>
<td>June 15, 2007</td>
<td>Variable, to 1 meter SAR</td>
<td>2.5 days</td>
<td>Germany</td>
</tr>
<tr>
<td>WorldView-1</td>
<td>September 18, 2007</td>
<td>.5 meter panchromatic</td>
<td>1.7 days</td>
<td>USA</td>
</tr>
<tr>
<td>CosmoSkyMed-2</td>
<td>December 9, 2007</td>
<td>SAR</td>
<td>Few hours in constellation</td>
<td>Italy</td>
</tr>
<tr>
<td>RADARSAT-2</td>
<td>December 14, 2007</td>
<td>Variable to 1 meter SAR&lt;sup&gt;b&lt;/sup&gt;</td>
<td>N/A</td>
<td>Canada</td>
</tr>
<tr>
<td>Cartosat-2A</td>
<td>April 28, 2008</td>
<td>&lt; 1 meter panchromatic</td>
<td>4 days</td>
<td>India</td>
</tr>
<tr>
<td>GeoEye-1</td>
<td>September 6, 2008</td>
<td>0.41 meter panchromatic</td>
<td>&lt; 3 days</td>
<td>USA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.65 meter multispectral&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CosmoSkyMed-3</td>
<td>October 25, 2008</td>
<td>SAR</td>
<td>Few hours in constellation</td>
<td>Italy</td>
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</tbody>
</table>
Regarding the three key metrics used in this study, one can see a steady advance in the technical capabilities of commercial satellites

By 2014, it had become apparent that the U.S. remote sensing industry could not compete with emerging foreign competition without a change in the resolution limits established by the Department of Commerce. In June 2014, a fifty-centimeter spatial resolution limitation was lifted. From early 2015, the limit would be reduced to 30 centimeters. That change applied immediately to GeoEye-1 and WorldView-2, which have the technical capacity to take panchromatic images at resolutions of 41 and 46 centimeters, respectively. Both of these satellites are owned and operated by DigitalGlobe, an American company. In August 2014, DigitalGlobe launched its WorldView-3 satellite, which has a thirty-one-centimeter resolution in the panchromatic range and is capable of collecting up to 680,000 square km per day.38

Spatial resolution alone may not matter as much as other technical characteristics. What is analytically possible with thirty-centimeter resolution imagery may not outweigh what one can be accomplished with a one-meter spatial resolution satellite with a high temporal resolution. In other words, “good enough” one-meter spatial resolution

images that are updated rapidly can be more important to understanding a situation, especially in quickly evolving crises. Pleiades-1A and 1B and Cosmo SkyMed satellites operate as a constellation of compatible sensors. Yet constellations of satellites are expensive. Reaching back to Keyhole and other government satellites, conventional imaging satellites are designed for government needs, with each one costing about $800 million and their sizes and weights (about two tons) making them expensive to launch. A different model began to emerge in 2014. Companies using off-the-shelf components and open-source software began to build satellites weighing only about 200 pounds. So-called CubeSats, measuring about 30 x 10 x 10 centimeters or less, were the inspiration of this new generation of remote sensing satellites. Their simplified manufacturing process and reduced weight means they are less expensive to build and put into orbit. Ninety-two CubeSats were launched in all of 2013. By the first half of 2014, 122 satellites with masses between one and fifty kilograms (2.5 - 110 pounds) had been launched. By comparison, 92 CubeSats were launches in all of 2013. Most of the growth in CubeSats is found in the remote sensing sector.

Analysts forecasts anticipate that fifty-two percent of launches between 2014 and 2016 will be devoted to remote sensing CubeSats, whereas only twelve percent were used for remote sensing between 2009 and 2013.40

There are at least four firms pursuing the development of large constellations of remote sensing CubeSats. Skybox, now owned by Google, is probably in the strongest position to succeed. In November 2013, Skybox launched SkySat-1. One month later, it revealed its first images, followed quickly by an unveiling of the first video taken by a commercial satellite. The videos allow for clear tracking of automobiles and other vehicles—even airplanes flying across the sky far below the satellite. Eventually, the company hopes to have a constellation of twenty-four satellites in orbit.

Planet Labs, another CubeSat company, is pursuing the deployment of over one hundred medium-resolution remote sensing satellites. Its first “flock” of twenty-eight satellites was delivered to and then deployed by the International Space Station in January 2014. Planet Labs plans to launch a total of 131 satellites by mid-2015.41 With that many almost identical satellites in orbit, one filling in for another in a synchronized orbital rotation, temporal

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resolution will be measured in hours at most.\textsuperscript{42} And of course the Pléiades and Cosmo SkyMed systems already work cooperatively to produce high-resolution radar and optical data with temporal resolution measured by hours.

Another example of constellations lowering the temporal resolution of remote sensing is the Disaster Monitoring Constellation (DMC). DMC consists of satellites constructed by Surrey Satellite Technologies, a British firm. DMC International Imaging, the company that manages the DMC, operates the satellites for the Algerian, Nigerian, Turkish, British and Chinese governments. DMC’s purpose is to provide emergency Earth imaging for disaster relief under the International Charter for Space and Major Disasters. The International Charter on Space and Major Disasters provides for the charitable acquisition of and transmission of remote sensing data to relief organizations in the event of major disasters.\textsuperscript{43}

These are some of the major developments in commercial remote sensing since mostly 2000. The chief attribute of the commercial satellites may not be spatial resolution. It really depends on the purpose of the image. “Good enough” one-meter resolution that can be updated in hours may be the more important attribute. And of course geospatial data are important, too. How might satellite data affect the regulation of violence in areas of limited statehood?


\textsuperscript{43} www.disasterscharter.org
Remote Sensing and the Regulation of Violence

The principal objective of this paper is to consider the possible role of remote sensing satellites and geospatial data in areas of limited statehood. Governance refers to “the various institutionalized modes of social coordination to produce and implement collectively binding rules, or to provide collective goods.”44 Gregor Walter-Drop and I have focused on the affordances or efficiencies created by information and communication technology (ICT) in the provisioning of collective goods, either by states or by alternative governance modalities, such as NGOs and community-based organizations. Similarly, Krasner and Risse have recently highlighted the provisioning of collective goods by external actors.45 Less attention has been given to the possible roles of ICT in the enforcement of binding rules. There is, of course, a great deal of academic and popular attention paid to the use of ICT by states for surveillance of domestic and foreign populations. While that is an important issue, my focus here is on the use of ICT by nonstate actors in their effort to monitor violence by states.

Put differently, I am interested in the use of remote sensing satellites for what might be called the “regulation of violence.” How might ICT regulate the use of force by those who assert a responsibility and right to enforce binding rules, but who tend to do so poorly or with excessive and indiscriminant violence? The reference to “regulation” is metaphorical; it is intended as a short-hand reference to efforts by nonstate actors to, first, identify transgressions of broadly recognized international norms and, second, to put pressure on those who are responsible for the transgression. The objective is to stop the transgressions, in part by shedding light on them and by holding those responsible for past transgressions accountable.

Max Weber’s classic definition of statehood highlights the role of force or violence in state-based governance. “The modern state is a compulsory association that organizes domination. It has been successful in seeking to monopolize the legitimate use of physical force as a means of domination within a territory.”46 In an area of limited statehood, this ability is somehow impaired. A weak or limited state is unsuccessful in its efforts to provide collective goods and its enforcement of binding rules with the use of force. At times, the state’s legitimacy—to the degree it has it—is undermined by the way force is employed. My interest centers on the possible role of ICT in addressing the maladroit use of force.

An enormous number of research questions emerge from a consideration of the enforcement of binding rules by various governance modalities or combination of modalities. Intuitively, one would assume that different governance modalities—NGOs, INGOs, firms, and clan systems—enforce binding rules in different ways. Identifying the full range of governance modalities and possible maladroit enforcement of binding rules would itself constitute an important research project. This paper cannot adequately cover all permutations found in security provisioning and enforcement of binding rules by an empirically legitimate use of force across all variations of governance. Instead, it will focus on the digital regulation of violence in a particular governance space. It can be specified by the following terms:

1. It involves violence in sectorial, spatial, temporal, or social areas of limited statehood.
2. State actors, such as police, military, or other state security personnel, or their designated surrogates, such as private security firms or allied militias, are the agents of violence.
3. Local and global nonstate actors—transnational advocacy organizations—attempt to regulate these state actors in response to their maladroit use of force. In most cases, the use of force in question constitutes a violation of broadly recognized international norms.

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44 Risse, 2011, p. 9, emphasis added.
46 Weber, p. 4.
In sum, I am interested in the use of remote sensing and other ICTs by nonstate actors who hope to alter the behavior of state actors who have or are using force in such a way as to violate broadly recognized norms. A part of this process is verification of such an abuse.

Where states are functioning or consolidated, the regulation of violence is often performed by official oversight offices or by civilian oversight commissions established by the state. Technologically enabled nonstate actors’ regulation of violence can be seen as a functional equivalent of these state administrative entities. Where the state is too weak to hold its own security forces to account and to monitor, investigate, and verify the nature of their conduct, nonstate actors fill at least some of the void. *Nonstate actors offer a functional equivalency to a consolidated state’s oversight functions.*

Human rights monitoring groups such as Amnesty International and Human Rights Watch are counted among the nonstate actors involved in the regulation of violence. In a different manner, various forensic anthropology organizations create a factual basis for verifying human rights abuses by state agents. Examples would include the Argentinian Forensic Anthropology Team, the Guatemalan Forensic Anthropology Foundation, the Peruvian Forensic Anthropology Team, and the International Commission on Missing Persons, an intergovernmental organization established by several states to investigate the Srebrenica massacre and other human rights atrocities of the Bosnian civil war.47

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DNA matching in the identification of human mortal remains offers one example of nonstate actor regulation of violence. In the Balkans, Guatemala, and Peru, among other locations, nonstate, NGO-coalitions have used advances in DNA analysis (an information technology in the sense that the human genome is mapped only with the assistance of powerful, high-speed computers). Once the remains have been positively identified, the evidence becomes the basis for various sorts of criminal prosecutions (which is in itself an interesting aspect of the regulation of violence), as discussed by Kathryn Sikkink.48

Another example of the use of ICTs for the regulation of violence is found in groups that use data from high-resolution remote sensing satellites that are owned and operated by commercial firms. Amnesty International, Human Rights Watch, the American Association for the Advancement of Science, the Institute for Science and International Security, and the Satellite Sentinel Project all offer examples of NGOs using remote sensing geospatial data in their advocacy work.49

Remote sensing and GIS are used to monitor compliance with broadly shared international norms in East Africa. DigitalGlobe, a remote sensing information company, and Enough, a human rights advocacy organization, have

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partnered to create the Satellite Sentinel Project (SSP). It uses DigitalGlobe’s satellite imagery to monitor conflict in the South Sudan.

In an effort to avoid confrontations, Sudan and South Sudan agreed in September 2012 to create a 12.5-mile (20 kilometer) demilitarized zone along their shared border. The agreement required both sides to remove military forces and equipment from the buffer zone and establish a verification mechanism. Although both countries agreed to implement the agreement in March 2013, SSP determined that both countries remained out of compliance as late as June 2013. Using DigitalGlobe satellite imagery acquired in May and June 2013, several violations were evident:

Satellite imagery supports the conclusion that the Sudan Peoples Liberation Army, or SPLA, maintain military installations or checkpoints in at least nine locations along the border, while the Sudan Armed Forces, SAF, have positions in at least five locations along the border, some with visible tanks and heavy artillery.50

Images captured on February 13, 2012, May 6, 2013, and June 3, 2013 (see Figure 6) show a Sudanese infantry company, including howitzers, tanks, and several tents that presumably cover more tanks, all in the demilitarized zone. Figure 7 identifies elements of an SPLA (South Sudan) infantry unit also found in the demilitarized zone. Figure 8 identifies something as small as a platoon-size force in violation of the agreement.

In another example, SSP has relied on DigitalGlobe imagery to monitor and document harm done to civilians caught in battles between the Sudanese Armed Forces and the rebel Sudan Revolutionary Front (SRF). The burning of several villages and repeated indiscriminate bombing of civilian areas in Abu Kershola are clearly evident in the images. Figure 9 notes the extensive presence of bomb craters scattered about Abu Kershola.

Figure 10, another image taken on April 22, 2013, shows the charred remains of the village of Ad Dandour.

Less dramatic examples of monitoring and evaluation initiatives using commercial imagery can be offered as well. For example, evaluation of present vegetation cover and health in comparison with past imagery – factoring in other environmental variables such as ocean temperatures – is used to predict drought conditions in East Africa. Finally, remote sensing data and GIS rest in the background of all “crisis mapping” initiatives. Examples include the first deployment of the Ushahidi open-source GIS platform used to monitor post-election violence during the 2007-08 Kenyan elections. Since its launch, anywhere in the world where Ushahidi has been used to crowdsourc

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51 Civilians Caught in the Crossfire: The Bombing of Abu Kershola and Burning of Ad Dandour, Satellite Sentinel Project

referenced spots, the same geospatial awareness is relied upon.

These are just a few examples of the use of remote sensing in the regulation of violence in areas of limited statehood. How might these developments be articulated in the theoretical literature of political science? It has already been noted that the limited statehood literature frames the consideration of conditions leading to the use of indiscriminate, undisciplined violence by the security forces responsible for the provisioning of individual and collective security. To account for the use of remote sensing by nonstate actors requires another theoretical anchor.

Margaret E. Keck and Kathryn Sikkink’s “boomerang model” of transnational advocacy offers a way to understand this process. According to the boomerang model, NGOs in a country experiencing violations of broadly recognized international norms make appeals to the NGOs, foundations, and state institutions of another country in an attempt to convince them put pressure on the state that is in violation of norms. Together, transnational NGOs, international organizations, and some state institutional coalitions create what Keck and Sikkink call Transnational Advocacy Networks (TANs). Verification processes of the alleged violations are an important part of the process. At the heart of TAN work is a dense exchange of information and services. “What is novel in these networks is the ability of nontraditional international actors to mobilize information strategically to help create new issues and categories and to persuade, pressure, and gain leverage over much more powerful organizations and governments.”

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54 Keck and Sikkink, Kindle Locations 159-160.
Lacking more traditional avenues of success in political influence, such as money and force, they "must use the power of their information, ideas, and strategies to alter the information and value contexts within which states make policies."55

TANs use commercial remote sensing satellite data to "map" the range of possible unregulated state violence. Mapping is the process of making illegible terrain clear to an outsider. Maps, as James Scott notes, are more than just maps. When allied with state power, "maps enable much of the reality they depicted to be remade."56 State simplifications of the kind examined in this paper are designed to provide authorities with a schematic view of their society, a view Scott assumes is not afforded to those outside the state.57

In this respect, Scott is wrong. States no longer enjoy a monopoly on the synoptic view of earth from space. From the vantage point of space, a précis of the entire earth is offered the user of commercial remote sensing satellite data. With private satellite technology, legibility as Scott describes it has been decoupled from the state. Nonstate actors, from corporations to nongovernmental organizations and community groups now have access to the means of ordering a disorderly world on their own terms.

55 Keck and Sikkink, Kindle Locations 390-391.
56 Scott, p. 3, Kindle
57 Scott, p. 79 Kindle