Satellite Remote Sensing and Database Management

Who Owns Digitalization of Indigenous Peoples, Antiquities and Their Artifacts

By Brenda Reddix-Smalls[1]

Abstract

'Satellite Remote Sensing visualizes the confluence of human history and the environment'"[2]

'Satellite Remote Sensing is the specific application of satellite imagery (or images from space) to archaeological survey (Zubrow 2007, Parcak 2012)'. One surveys by searching for [ancient] sites on a particular landscape at different scales (Wilkinson 2003, Parcak 2012). Geographic information systems (GIS) and satellite imagery analysis are forms of remote sensing. Remote sensing, a term which refers to the remote viewing of the surrounding world, including all forms of photography, video and other forms of visualization (Parcak 2012) can be used to view live societies. Satellite remote sensing allows the scholar to see an entire landscape at different resolutions and scales on varying satellite imagery datasets, and to record data beyond the visible part of the electromagnetic spectrum.[3]

I am concerned with indigenous knowledge, settlements and how the current intellectual property laws[4] *and the use of technology data collection*[5] *as*

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[2] Sarah Parcak, Satellite Remote Sensing for Archaeology, (Springer Books 2012)(2009). I am deeply indebted to Parcak's work on Satellite Remote Sensing for Archaeology.

[3] Id.

[4] Michael J. Huft, Indigenous Peoples and Drug Discovery Research: A Question of Intellectual Property Rights, 89 NW U.L. Rev. 1678, 1730 (1995) :"Even as the rapid depletion of much of the world's biological diversity, particularly in the tropics, is becoming a major item of public awareness, the great potential of that diversity for food, medicines, and other products yet undreamed of is only beginning to be understood. Thus the importance of biological conservation now has an economic as well as an aesthetic and scientific, importance. ..A second issue affecting biological diversity has gained importance…[this] is the realization that indigenous peoples around the world have developed a profound and extensive knowledge of the uses of the biological resources in their environment and that their knowledge is of inestimable value to Western interests in developing those resources for use in modern society.":;See also, Leo B. Malagar et al., International Law of Outer Space and the Protection of

evolved have helped to displace property identities of black, African, Natives[6] and Hispanics in the Americas.[7]

Recently two scientists used Google Earth satellite imagery to estimate the area of the fields and the size of the village of a remote tribe in Lowland South America, surrounding the Amazon Basin. This is reportedly one of the last indigenous' societies having limited contact with the outside world. The remote surveillance is purportedly the only method to track un-contacted indigenous societies.[8]

Intellectual Property Rights, 17 B.U. Int'l L.J. 311, 348-353(discussing intellectual property rights in remote sensing activities in outer space).

[5] Alexandra Rengel, Privacy Invading Technologies and Recommendations For Designing a Better Future for Privacy Rights, 8 Intercultural Hum Rt. L. Rev. 177, 184, 186: "Three relatively recent major digital developments have affected our concept of privacy greatly: (1) the increase in data creation and the resulting collection of vast amounts of personal data—caused by the electronic recording of almost every transaction; (2)the globalization of the data market and the ability of anyone to collate and examine this data; and (3) the lack of the types of control mechanisms for digital data that existed to protect analog data." More troublesome from the vantage point of dis-advantaged citizenry is the use of biometrics: "[t]he operation of collecting, synthesizing and subsequently storing data relating to a particular individual's characteristics—physical, genetic or otherwise –for identification purposes. Various forms of biometric technology are being used worldwide in such places as government agencies, education centers, police departments, automated bank devices and retail establishments." The use of this biometric information could pose a problem for socio-economic disadvantage citizens, without access and knowledge.

[6] Huft*, supra* note 4 at 1730: " A consideration of the social and political context in which indigenous knowledge contributes to drug development makes it obvious that while intellectual property rights may at sometimes be a serious consideration in the use of indigenous knowledge, these rights are unavailable for other types of collaboration. From an equitable viewpoint, however these other types of collaboration may also deserve some type of return of benefits to the indigenous peoples whose knowledge is used. "

[7] Paul Gordon Lauren, The Evolution of International Human Rights: Visions Seen 38 (Univ. of Pa. Press 1998): "But what began to emerge during the sixteenth century with the first shipments of black Africans to the western Hemisphere eventually profoundly altered patterns of slavery. In terms of numbers totaling in the millions, systematic focus on one particular race, creation of an ideology extolling racial superiority and a practice establishing racial segregation between masters and slaves, lucrative financial rewards, and impact on four continents, black slavery had no parallel in history. Few wanted to be left out of this enterprise and thus deny themselves either the power or the profits that flowed from it. For this reason, and up to the beginning of the nineteenth century, the international slave trade flourished and human bondage in slavery was legally practiced in most countries of the world."

[8] *See*, Walker & Hamilton, Amazonian Societies on the Brink of Extinction, American Journal of Human Biology 26:570-572 (2014) "Greater Amazonia harbors as many as 100 locations of isolated indigenous peoples. Few options are available to assess the demographic health of these populations given their limited contact with the outside world. Remote Sensing offers one option." "An isolated village in Brazil near the Peruvian border is visible with Google Earth imagery from 2006. The area of the fields and villages, as well as the living area of the other four longhouses, are measured and compared to population by area measurements for 71 other Brazilian indigenous communities. The estimated population of the village is no more than 40 people. A village as small as this one, if it has become disconnected from a meta population, risks imminent extinction if it has fallen below a minimum viable population size. Conclusions: An active remote surveillance program is urgently needed to track the

Is this information gained a cultural or tribal property interest? Do indigenous peoples, antiquities, their farming methods, their building efforts, their migratory patterns belong to Google's database, or solely to the Universities? [9] *Is there an ethical clarion to apply the appropriated knowledge gained through technological non-consensual intrusions to the indigenous people?*[10] *Is there a human right involved in the remote viewing of the day to day activities of people separated by cultural differences?*

I propose to examine the technology which allows Google Earth to map, identify, hidden indigenous people, their artifacts, buildings, cultural and geophysical property location; and to examine the ethical obligations in utilizing such database information.

A. Technology Applicable to Earth Remote Sensing

A. Technology

Satellite remote sensing technologies have been developing since the early twentieth century. The specific term 'satellite remote sensing' has been defined as using imagery from space and applying them to archaeological surveying, while searching ancient sites on a specific landscape at different scales.[11] Remote sensing which is as ancient as the existence of human culture entails the human observation of the existing landscape.[12] When humans

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movements and demographic health of isolate peoples in hopes of improving their dire chances for long term survival. They need protected areas that are large enough to mitigate against external threats. Am J. Hum Biol. 26:570-572, 2014.

[9] See, Kelly M. Zullo, 90 Geo. L.J. 2413,2436 (arguing that all states benefit from satellite remote sensing data, which is used for beneficial purposes such as protecting the environment and forecasting the weather and providing valuable communications and thousands of employment opportunities throughout the world. Further she argues that commercial enterprises bear the risks and are discovering ways to exploit natural resources in space profitably but need a legal regime which can provide certainty in their investments.)

[10] Having recently attended a Native American cultural powwow (the Lumbees) who are also closely aligned with African Americans in North Carolina (May 2nd –May 4th, 2014); I observed the utilization of group cultural normative activities which are appropriated by tribal ownership. Such tribal activities seem ill fitted to the current copyright regime-in costume, dance, language, art ware.

[11] *See, supra note* 2 Parcak, Satellite Remote Sensing for Archaeology, Routledge, London and New York (2009)

[12] Id at 13 In fact hunter gatherer societies engage in remote sensing when using landmarks such as mountains, cliffs, mounds, far off forests to identify hunting, trapping and living locations. *CF FN 2*, at 13: "Many ancient cultures used mountain peaks or desert cliffs to survey their landscapes prior to choosing the most advantageous

apply interpretation to their remote sensing activities using visual data, they are engaged in the qualitative and quantitative examination of images in order to identify objects and evaluate their significance.[13]

Remote Sensing technologies, on the other hand, obtain data such as measurements of electromagnetic energy from distant targets which enable the viewer to extract information about features, and objects on the Earth's land surface. The 'interpretation of geospatial data is possible because objects made of diverse materials emit and/or reflect a different quantity of energy in diverse regions of the electromagnetic spectrum.'[14]In viewing these multi-spectral images, an observer sees pixels. Each pixel has a set of spectral values and can be charted as a vector in a multi dimensional space whose 'axes correspond to the given image band in the multi spectral image space.'[15]

> Therefore, on the basis of spectral content we can identify and categorize the diverse surfaces (soil, vegetation, sea), materials (soil types, vegetation cover types, concrete) and objects (urban areas, archaeological feature) by classes or types, substance, and spatial distribution according to their specific characteristics (fresh snow, senescent vegetation, clear water, moisture content, grain size). The different spectral responses observed for diverse materials according to their characteristics, is generally known as spectral signatures.[16]

The scientific community engaged in archeology, geo-archeology, paleo-environment, paleo-climate and cultural heritage research has utilized various forms of remote sensing coupled with advancing technologies to further scientific inquiry. The pertinent inquiry for a review of remote sensing

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positions for their temples, tombs, settlements, or other building projects….they focused on the natural relationship of landscape features to potential places for living burial or worship."

[13] Rosa Lasaponara & Nicola Masin, Satellite Remote Sensing, A New Tool for Archaeology, Springer Dordrecht Heidelberg, London New York (2012)

[14]Id.at 66

[15] Id. at 66

[16] *Supra*

technology, policy and intellectual property is: to whom do the spectral signatures identified as humans belong? [17] The question is germane where the scientists are not observing or identifying ancient buried artifacts or surveying ancient sites but are identifying and storing knowledge of extant human societies.

Where the indigenous societies neither give their consent for observation nor for data storage does remote satellite viewing violate imperatives for the preservation of human rights or the infringement of intellectual cultural property rights?

Routinely, utilizing visual tools, observers use knowledge, experience and cultural perspectives to gain entry into indigenous communities to preserve, exploit, examine, record and identify cultural artifacts, habits, lives, antiquities and traditional knowledge based information. This information, i.e. spectral signatures, then becomes data, data stored, data analyzed, interpreted and commodified by commercial entities.

Visual identification and ultimate data analysis is cheap, simple and can be completed when features or objects are not easily identifiable. As a limitation, although relatively inexpensive, visual interpretation of surface areas must be conducted in small confined areas.[18] The advancement of technology for remote viewing data analysis provides expansive improvement. [19] The utilization of computers and data analysis can provide the observer with sufficiently large data sets to enable quantitative analyses of information; and allows the extraction and interpretation of data for large areas to become much easier to conduct by the scientist. Currently, technology in remote

[17] Mary G. Leary , The Missed Opportunity of United States v. Jones-Commercial Erosion of Fourth Amendment Protection in a Post-Google Earth World, 15 Journal of Constitutional Law 331,365,(2012) ;http://ssrn.com/abstract=2148591: "The problem is really who owns a person's 'digital dossier' or digital identity. 'Palfrey and Glasser describe [it]i.e. a digital dossier as all of the personally identifiable digital information associated with one's name, and they further discuss one's digital identity as a subset of information 'composed of all those data elements that are disclosed online to third parties, whether it is by [one's] choice or not.' *Cf* John Palfrey & URS Gasser, Born Digital: Understanding the First Generation of Digital Natives 40 (2008)

[18] Lasoponara*, supra* note 13 at 8.

[19] Id at 8.

sensing allows remote sensing data to be compiled in a digital format and subsequent digital processing. As one scholar has observed:

> Compared to visual data inspection, digital processing offers several advantages such as, the possibility to: (1) perform repetitive and cost effective data analyses for large areas of cultural interest, (ii) obtain consistent results based on "objective" instead of subjective evaluations, (iii) facilitate the integration of imagery with other data source (archaeological record, documentary sources, etc.), (iv) explore alternative data processing methods and (v) if required, also to apply complex algorithms to make archaeological information extraction and interpretation easier."[20]

Remote sensing in its most complete definition includes balloons, kites, drones, satellite imagery and aerial photographs.[21] Satellite imagery and its mapping products combine 3-D buildings and terrains in high resolution images. Until the advent of commercialization of remote satellite imagery, only military analysts, academics, spies and professionals had access to satellite images. Currently, worldwide public access to these images are now available via the internet to almost anyone with a computer access.[22]

To understand, the trajectory of the use of satellite remote sensing in the scientific field, one must begin with its history, wartime aerial photography definitions of satellite imaging and its use in archaeology. (See attached charts (Parcak 2012) for informational access to the commercial satellite imagery sources.)

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[20] Id.

[21] Id.

[22] Brian Craig, Online Satellite and Aerial Images: Until the Dawn of the New Millennia, Issues and Analysis, 83 N.D.L. Rev. 547, (formerly only military analysts, spies, specialist academics, and GIS professionals had access to satellite images prior to private commercialization)."Since 1972, the private satellite industry continued to grow and expand. According to the Satellite Industry Association (SIA), the premier trade organization representing the global commercial satellite industry, the 2005 total worldwide satellite industry exceeded $88 billion in revenues with $52.8 billion in revenues derived from satellite services such as satellite imagery."

Aerial Photography

Photography taken for military purposes during World War I by air pilots perhaps began the era of technical remote sensing. Aerial photographs taken in early 1906 by a UK army pilot who took photographs of Stonehenge, ushered in the use of remote sensing for archaeology by air. From the 1920s through the 30s aerial photography was used for archaeological purposes by the varied German Air Force (1917-Negev); Bavaria (photos of Israel and Jordan) taken by the Ottomans, and The Royal Air Force in 1923. "Archaeologist also used early aerial photography for archaeological site management and protection, during World War II, while German (Crashaw 2001; Going 2002), American, and British armed forces photographed a majority of Europe for military reconnaissance purposes."[23]

After World War II aerial photography, which expanded rapidly with reconnaissance of Europe, the Middle East and the far east, utilized advancing technology with the application of infrared photography."Advances in spatial remote sensing from the mid-1940s to the 1950s occurred with the V2 rocket launching in New Mexico, at the White Sands Proving Ground"[24]. Notwithstanding the lack of clarity in these photographs, the value of remote sensing imagery from space became well established.

In the 1960s satellite applications progressed based on government increased funding after the Soviet Union's Sputnik launch. [25] There are many advantages for archaeological and other scientific research with aerial photographs. Photographs can be taken vertically, obliquely, and with a three dimensional viewpoint. In addition, they can be easily interpreted by the somewhat experienced user.[26]

Television and Infrared Observation Satellite (TIROS)

[23] Id at n 13 " Some of these photographs are stored in archives, such s Smithsonian Institution, the Aerial Reconnaissance Archives in Edinburg, and the JARIV-National Exploitation Centre archives in Brampton, UK".
[24] Id at n 13.
[25] Id at 1n 13. (The Soviet Union launched the Sputnik satellite in 1957.)
[26] Lasoponara, *supra* n 13.

In the 1960s the United States launched satellite capabilities which displayed meteorological patterns. Space images were taken and developed. Space imaging programs: Corona, Argon and Lanyard, were developed which assisted with scientific activities involving global land space land coverage images. Today in some countries the data source for remote sensing is restricted from using aerial photography for military reasons. "After the end of the Cold war, in the 1990s, Russian and American intelligence satellite photographs were made commercially available for civilian purposes."[27] Russia declassified its data for four years. Thus usage of American declassified information KH-4B Corona has been increasingly used by scientists.[28]

LANDSAT

In 1967, the United States through its Department of the Interior began a program called the Earth Resources Technology satellites (ERTs). The aim of the program was to promote the use of land remote sensing data accumulation. Amidst fanfare, the program ERTS-I was launched with invitations to global scientists to study data collected by the satellite.[29] Renamed **LANDSAT** in 1975, the Reagan Administration (in 1984) sought to commercialize and privatize the **LANDSAT** program. With disappointing outcomes the program was returned to the US government, 'with private industry competition for government contracts to market and commercially disseminate the obtained data. '[30]

Global Positioning System (GPS)

The U.S. Department of Defense introduced the global positioning system technology in 1973. It was offshoot of research utilizing satellite navigation for military uses. It garnered expanding civilian usage in 1996 when the military allowed greater access to satellites for civilians. Vehicles were equipped with

[27] Lasoponara at 10.
[28] Id.
[29] Parcak supra n 4 at 22.
[30] Langston supra n 14 at 281.

devices which could either be fixed or removed. These devices allowed locations to be ascertained by triangulating mapping information using the technology. [31]

SPOT 4, IRS-1C, Landsat 7, IKONOS

(SEE Attached Charts)

GOOGLE

A company which began as a search engine, Google derives its name from the mathematical term, 'googol' which means the number one (1) followed by 100 zeros , representing the immense volume of information available in the world. Google's mission remains 'to organize the world's information and make it universally accessible and useful."[32]

Without rehashing numerous scholarly articles concerning the co-operation between Google and the government, companies like Google may invade an individuals' privacy by storing and tracking their data.[33]

> As one scholar opined, perhaps futilely: "[B]ecause of the spotty coverage and overall inadequacy of American privacy law and combined with the frightening power of Google, Facebook, and other private corporations that are compiling massive databases of information about people for profit and sharing those databases with governmental agencies, Congress should act now to create a comprehensive, coherent privacy statute."[34]

[31] Alexandra Rengel, Privacy Invading Technologies and Recommendations For Designing a Better Future for Privacy Rights, 8 Intercultural Hum. Rts. L. Rev. 177, 207.

[32] Corporate Information, Company Overview, Google, http://www.google.com/corporate/index.html (2014)); See also, Stephanie A. Dvos, The Google-NSA Alliance: Developing Cybersecurity Policy at Internet speed, 21 Fordham Intell. Prop. Media & Ent. L.J. 173, 190.

[33] Id at 747; Only two statutes prohibit companies like Facebook and Google from invading an individuals' privacy by storing and tracking their data: Children's Online Privacy Protection Act of 1998; and the Electronic Communications Privacy Act which is totally ineffective.

[34] *Supra*

GOOGLE EARTH[35], GOOGLE STREET VIEW [36]AND GOOGLE MAPS[37]

Originally Google Earth was a company called Earth Viewer started by Keyhole, Inc., and acquired by Google in 2004. Google changed the name (2006) and developed a virtual 3D imagery and topographic data base from multiple satellite image types, aerial photographs and Shuttle Radar Topography Missions. It is a publicly available resource with high resolution sensing capabilities. Using Google Earth people can zoom in 'on a target on a satellite image to see a mound, monument or even military installations.[38]

GOOGLE Earth is free, but there may be restricted access to this site in some developing nations. Yet the use of Google Earth can provide wide format maps for publications and in field use. [39]

Google Street view allows a user to zoom in on images beyond what the ordinary viewer can see, by providing panoramic views of streets on all seven continents. Google acquires these images by using a fleet of vehicles with cameras and Wi-Fi antennas mounted on cars which capture and store wireless data.[40]

> The first distinguishing feature of image capture and other data gathering technology used by mapmakers and other contemporary aggregators of images is their enormous scale. Photographers and videographers of the past could shoot and build image libraries of only the spaces they inhabited. Indeed, they could join with others to build a comprehensive visual library of images, covering stretches of time and space that go beyond any one person's experience. But before the emergence of the World Wide Web and the widespread adoption of Internet communications outside of government and academia, such

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[35] GOOGLE EARTH, http://www.google.com/earth/index.html (last visited July 28, 2014)
[36] GOOGLE STREET VIEW, GOOGLE MAOS http://www.google.com/streetview(last visited)
[37] *Supra* 13: "The ability to engage in this surveillance is possible through a combination of satellite imaging technology and software processing. Satellite imaging technology is a component of currently existing technology that allows one to access images of a specific location in the world and zoom in to obtain a view from the equivalent of approximately five meters away.
[38] Pacak,pg 48.
[39] Id at 48.
[40] See About Google Maps, Google Maps http://,aps.google.com/support/bin/answer.py?hl=en&answer7060 a user can "view a satellite image or a satellite image with superimposed map data of your desire location that you can zoom and pan.")

> aggregation was a laborious task. Modern software companies, by contrast can aggregate and stitch together numerous images into a mosaic of a vast environment, a service offered by Microsoft's Photsynth. Computer generated maps, drawing on incredibly large batch of images and other data from satellites, airplanes, and trucks, electronically recreate not merely a large public space, but the entire Earth and overlay it with multiple layers of information that user may select to learn about present or historical facts related to each mapped location.[41]

Google contracts with and uses satellites owned by third party operators, some private and others government agencies. These third parties have numerous satellites. These satellites travel orbits that allow them to orbit the earth. They collect images, upload, store transmit and process these images on the Internet.[42] Some of these satellites are owned by or have close ties to governmental agencies. The Spot 5 Program is owned by CNES, the French government. It carries enhanced viewing instruments that can acquire repeat coverage of vast areas yielding detailed images.[43]

Google also maintains a contract for the online usage of imagery supplied by GeoEye, a company with close contractual ties to the National GeoSpatial Intelligence Agency.[44]

GIS (Computerized Geographic Information)

This is technology which allows mapmakers to add, and map users to select, layers of additional information to geographic charts; additional computer chips then allow maps to add additional amounts of information.[45]

[41] Marc Jonathan Blitz, The Right to Map and Avoid Being Mapped: Reconceiving First Amendment Protection For Information Gathering by the Age of Google Earth, 61 Colum. Sci & Tech. L. Rev. 116, (2013)
[42] Id.
[43] Id
[44] Id at 350.
[45] Roger F. Tomlinson, Thinking about GIS 101-107(3d ed 2007).

B. THE LEGAL FOUNDATION APPLICABLE TO SATELLITE REMOTE SENSING

Remote sensing activities have as their legal foundations several international conventions: [46] (1) the Outer Space Treaty, the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies,[47] (2) the Liability Convention, 1972 Convention on International Liability for Damage Caused by Space Objects,[48] and (3) the Registration Convention, 1975 Convention on Registration of Objects Launched into Outer Space.[49] Two other instruments germane to remote sensing activities are the UN Resolution 41/65[50], known as the Principles on Remote Sensing and WMO Resolution 40.[51]

Articles I, II and VII of the Outer Space Treaty govern property rights issues. Article I states that "outer space is the providence of all mankind and that "exploration" should be "carried out for the benefit and interests of all countries, irrespective of their degree of economic or scientific development. Article II limits claims of sovereignty or appropriation to the moon and other celestial bodies. Article VIII mandates that states retain "jurisdiction and control" over objects and personnel launched into space.[52]

The United States codified Remote Sensing activities in the Land Remote Sensing Commercialization Act of 1984. The United States attempted to commercialize a program known as Landsat. Landsat was the world's first observation satellite system initiated by the United States in the 1970s during the heyday of the Cold War.

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[46] Sara M. Langston, Contemporary Issues and Future Challenges in Air and Space Law: A Comparative Legal Analysis of US and EU Data Access policies for Earth Remote Sensing; www.airandspacebooks.info

[47] Id.
[48] Id.
[49] Id.
[50] Principles Relating to Remote Sensing of the Earth from Outer space, UN Doc A/Res/41/65 (1986); Principles on Remote Sensing
[51] WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products Including Guidelines on Relationships in Commercial Meteorological Activities, WMO res. 40 (Cg-XIII)(1995)
[52] Zullo n 9.

As the first US remote sensing satellite placed into space (LANDSAT), it was previously known as the Earth Resources Technology Satellite. Four subsequent satellites under this program have been launched by the United States.

Landsat was designed to promote the private commercial use of land remote sensing data. However the attempt to privatize Landsat met with failure. The Land remote Sensing Commercialization Act, adopted two years before the Principles on Remote Sensing, failed to take into account market forces such as the high cost of value added services and the transient nature of new technology. The transfer of the LANDSAT system to the private sector in 1984 via the Land Remote Sensing Commercialization of 1984, was designed to avoid the overregulation and to create a private sector enterprise based on market terms.[53]

The United States has changed its policies since the inception of Landsat. The US has allowed for a flow of raw data and information from government sponsored Earth remote sensing programs to private remote sensing operators and contractors, for the dissemination and marketing of Landsat data. The US and Russia agreed as the two main space powers during the drafting of the Principles on Remote sensing which mirrored their state interests. The three key components were adopted in the Principles, which included (a) no prior consent from the sense state was needed; either for sensing or disseminating the data acquired by the satellites; (b) there was no priority for the dissemination of the sensed data; and (c) sovereign rights for the individual states were retained.[54]

More importantly, the private operators were granted copyright protection for data produced by their commercial systems. Intellectual copyright legal protection would pass from the government to the private owners of

[53] See, Leo B. Malagar et al, International Law of Outer Space and the Protection of Intellectual Property Rights, 17 B.U. Int'l L. J. 311, fn 255.
[54] Id.

LANDSAT, who 'would then negotiate sales contracts with the government as the need' arose. [55]

The former LANDSAT act provided that "private companies will have the exclusive right to sell all unenhanced data for the duration of the marketing contract with the government, not to exceed ten years from the date the data are sensed." [56]

It appears that proprietary rights to the unenhanced data has fallen into a limbo of ownership between the private commercialized satellite owner, the United States government and the sensed state. This leaves the query germane to this paper: who owns the rights to sensed data of indigenous peoples who did not give their consent for the remote viewing?

The U.S. code in the Land Remote Sensing Policy Act of 1992[57], established an official data archive for Landsat and other land remote sensing data. It provided for the commercial distribution of unenhanced data and value added services by the private sector.

This 1992 Act commercialized private remote sensing space systems. The licensing requirements do very little to protect the privacy of the sensed individuals. In fact the law simply requires the system to make the unenhanced data available to the government of a sense state, 'as soon as such data is available and on reasonable terms and conditions.

Critically important in this act, is that these principles do not impose an obligation on the private operator to provide the sense state's government with enhanced data or information. The Act does not require the private operator to provide nondiscriminatory access to its data and information. The Principles do not treat or address adequately private operators and commercial contracts.

[55] Id.
[56] Id.
[57] Supra n 45.

The U.S. has a variety of federal agencies which govern the management of operations involving remote sensing: NASA, National Oceanographic and Atmospheric Administration, National Geospatial Intelligence Agency and US Geological Survey.[58]

Policies at these various agencies mandate that data, information and all related products be released to the public as soon as available including agency generated standard products and source codes.

However, the term available is subject to interpretation. The government maintains legal ownership of some of this data but the data is made available via the internet.[59]

Finally, the United States in its Commercial remote Sensing Policy reserved the right to restrict sensitive data or control commercial remote sensing systems for national security purposes.

C. INDIGENOUS PEOPLE, THEIR ARTIFACTS, CULTURAL AND GEOPHYSCIAL PROPERTY

The decimation after contact with Europeans of the First people Americans in South America can be recounted as genocide, oppression and economic piracy.[60] Destruction of the indigenous people and disruption continued long after slavery was abolished.[61] Epidemics, induced and unintentional, conquest based on land robbing continued into the twentieth century. The estimates of native populations can be found in many scholarly works. Invasion of indigenous lands

[58] Id.
[59] Supra n 46.
[60] John Hemming, Red Gold, The Conquest of the Brazilian Indians, Harvard University Press (1978) During almost every year of the century from 1620 to 1720 there were official and unofficial slaving expeditions up the Amazon and its accessible tributaries. An average of perhaps one or two thousand Indians a year passed into the slave markets of Belem and Sao Luis do Maranhao: a total of 100,000 -200,00 during the century. Missionaries descended many other tribes, only to see them rapidly consumed in the disease ridden mission villages."
[61] Id at 490.

continues where natives have fought to retain recognized indigenous areas in Brazil. Invasion by loggers, ranchers, miners and squatters or roads, dams, power lines and railroads created in the name of progress also seek to undermine indigenous autonomy.[62]

Political autonomy for natives in the interplay of political, economic and cultural practices that shape the Latin America of today, with competing imperial designs, local interest, geo-cultural and geopolitical concerns continue unabated. The quest for power and dominance in Brazil by racial ethnic groups continues with the struggle for social justice.[63] Without resort to the economic history of the Amazon region and the political economy of Brazil it is difficult to have a meaningful discussion of the Amazonian Indians and their struggle for cultural and sovereign rights.[64] Without resort to the particulars of the Amazon and its bio-diversity interests, cultural imperatives for the indigenous people, one must assess the rights of a people to preserve their cultural identity without intrusions by others in the commodification of data compilation. The truth is that the Indian is not on the verge of extinction, nor can the indigenous groups be collected as one monolithic group. Their human rights cannot be denigrated and the use of technology to observe, collate and collect data cannot be conducted without resort to international law, ethics and human norms.

In discussing the property rights of indigenous people, it is easy to succumb to the western capitalistic framework of individualistic property ownership. That is to attempt to distribute property rights to individuals as opposed to a distributive formula based on communal or a collective basis for ownership. Intellectual property rights such as trade secrets, patents, copyrights and trademarks seem ill equipped to serve the needs of people living on their lands, claiming group ownership of traditional knowledge, and/or cultural based norms. However,

[62]Seth Garfield, Indigenous Struggle at the Heart of Brazil, State Policy, Frontier Expansion, and the Xavante Indians , 1937-1988 (200), Duke University Press, Durham & London, pg.215.

[63] See, Jonathan W. Warre, Racial Revolutions: Antiracism and Indian Resurgence in Brazil, Duke University Press (2001)

[64] See, See Shelton H. Davis, Victims of the Miracle, Development and the Indians of Brazil, Cambridge University Press (1997) 17.

because of the intrusion of commercial entities on traditional lands, indigenous people are often faced with conflicting and competing demands on tribal resources, conservation efforts, and cultural preservation and community assets. These demands are heightened in the face of group disparities of income and wealth based on historical inequities, oppressions and past genocidal harms.

Mark Hanning defines indigenous peoples to include those groups with some or all of the following characteristics:

a. Peoples who are descendants of the original inhabitants of a territory.

b. Nomadic or semi-nomadic peoples such as shifting cultivators.

c. Peoples without centralized political institutions who are organized at the level of the community.

d. Peoples who have all the characteristics of a national minority who share a common language, religion and culture.

e. Individuals who consider themselves as indigenous and are recognized as such.[65]

The use of remote sensing activities to acquire information about and concerning indigenous peoples, their artifacts, land, culture, farming mechanisms, languages, religions, and community mores, albeit for purportedly altruistic purposes is an unjust enrichment. Putting aside the issues of bio-diversity, plant and genetic resources, the gathering of data to inform and expand a knowledge base without consent, compensation, cultural protections simply ignores international law and borders on piracy.

Remote sensing utilizes a privacy invasive data collection mechanism whereby ownership of private information and resources is transferred to the data

[65] See, Solomon E. Salako, Agro-biotechnology, Indigenous Peoples Rights and Traditional Knowledge, African Journal of International and Comparative Law (2013); *Cf,* Mark Hanning, 'An Examination of the Possibility to Secure Intellectual Property Rights for Plant Genetic Resources Developed by Indigenous Peoples of NAFTA States: Domestic Legislation Under the International Convention for Protection of New Plant Varieties', 13 Arizona Journal of International and Comparative Law (1996): 175-252, at 178.

collector (either private or governmental user of remote satellites). The State of location may have given consent but the U.S. national and international laws utilized by the data collectors, (particularly in the Principles on Remote Sensing), adhered to by the United States are unethical. The US had three key interests in remote sensing which are contained in the Principles:

a. No prior consent from the sensed state is required, either for sensing or disseminating sensed data.

b. The U.S. ensured that there is no priority for the dissemination of the sensed data.

c. The states do have sovereignty over their own natural resources.[66]

The use of plants, pharmaceutical knowledge, genetic resources and the protections of their exploiters have been extensively discussed, debated if not resolved in the literature. In fact, the controversy surrounding WIPOs General Assembly Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore committee overview documents continues to underscore the divide between the technology rich industrialized countries of the north and the biodiversity rich developing countries of the tropics and Southern Hemisphere.[67]

For indigenous people, the rights to their territories resources, traditional knowledge and culture has been clearly outlined in the United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP).[68] Intellectual property rights, with its emphasis particularly on technology and the ownership of data acquired through technology cannot legally through international or national law serve the property interests of indigenous people. The following extant reasons

[66] Principles on Remote Sensing; See Sara M. Langston, A Comparative Legal Analysis of US and EU Data Access Policies for Earth Remote Sensing.
[67] See, Charles R. McManis, The Interface Between International Intellectual Property and Environmental Protection: Biodiversity and Biotechnology, 76 Wash. UlL. Quarterly 255(1998); See, also McManis Intellectual Property Genetic Resources and Traditional Knowledge Protection: Thinking Globally.
[68] United Nations Declaration on the Rights of Indigenous Peoples 2008; UNDRIP available at http://daccess-dds-ny.un.org/doc/UNCOC/GEN?NO6/52/67/PDF/NO65/207.pdf?Openelement

create an unjust enrichment: (1) the acquisition of data acquired through remote viewing of people is conducted without consent; and utilized without compensation; and (2) traditional knowledge for indigenous people is not associated with western versions of commerce, except for exploitation of resources.

Patent law is unsuitable for protecting traditional knowledge data collection because it is incongruous with holistic views and beliefs and those cannot be reduced to the finite regimes of intellectual property.[69] The novelty, usefulness and non obviousness requirements do not appear to apply to the traditional knowledge ascertained by remote viewing and used and collected or fit the plants, animals, buildings, cultural artifacts utilized by indigenous peoples without substantial changes to patent law. [70]T hus the rights of people in their ancestral lands and co-existence with the remote viewers cannot be neatly reconciled in patent law.

Trade secrets law requires secrecy and commercial benefits. In addition, independent discovery and use will certainly act as an impediment to the holding of trade secrets by a community which engages in a full exchange of information with its members.[71] Further, although the people are isolated, they don't even know that their information is being collected and used for commercial purposes.

[69] See Huft, (arguing that the rapid depletion of the world's biological diversity, and the great potential for that diversity in food medicines and other products is important, from a biological conservation standpoint as well as an economic, aesthetic and scientific vantage point. He develops a discussion on the uncomfortable fit of indigenous knowledge and drug development because of the rigid framework of intellectual property requirements in the patent area.) Huft also argues for a change in intellectual property laws to cover indigenous knowledge.

[70] Id at 1696-1728.

[71] See, Restatement of Torts, Secs 757 and 758;(in part) "A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business, and which give him an opportunity to obtain an advantage over competitors who do not know or use it."; Restatement Third of Unfair Competition Sec 39, cmt. (1995) provides that a trade secret means information, including a formula pattern, compilation, program ,device, method technique or process that derives independent economic value, actual or potential from not being generally known to, and not being readily ascertainable by proper means and is the subject of efforts that are reasonable under the circumstances to maintain its secrecy."

Trademark law requires a commodification[72] of traditional knowledge and resources and related biological expertise which does not augur well for this protection for indigenous people based on their communal use of knowledge, the lack of commodification of their lives and the existence of data extrapolated in secret and without their consent.

ETHICAL OBLIGATONS: OWNERSHIP ISSUES IN DATABASE INFORMATION

The use of remote sensing technology to preserve, protect the environment, prevent looting of artifacts, to monitor climate changes, to provide answers to historical and anthropological questions may merit the continued utilization of this technology. However as a developing field, the following ethical concerns must be addressed:

A. Accountability to the affected groups. Consent and equitable compensation for utilization of data sharing.

B. Publishing and Distribution of information concerning affected groups must be conducted with adopted and shared standards for ethical distribution. These standards should be both nationally and internationally acceptable to human study protocols.

C. Publication of data without techniques and appropriate training, and outreach should not be engaged in by data collectors.

D. Privacy protocols must be adopted prior to the engagement of research, study and data collection.

Addressing the issues of indigenous people; how can we ethically acquire information, cultural, traditional knowledge, and photographs about their bio-diverse habitat without either consent or compensation.

[72] See David C. Hilliard, et al, Trademarks and Unfair Competition (9th Ed) LEXISNEXIS (2012) "The fundamental principles of commercial identification remain viable today, even though their origins traced back into antiquity." p. 30"Trademark rights in the United States traditionally have been based on first and continuous use in commerce in connection with one's goods or services."

Arguments abound that a record should be maintained through remote viewing to provide for the continued welfare of the people; further that remote viewing provides the least intrusive method for creating that record.[73] Arguments are made also that the knowledge of the bio-diverse specimens in the Amazonian forest are germane for the survival of the human race. Scholars argue, that the survival of the forest is germane to abate issues of climate change; and the survival of a group of people is germane to continue the survival of the human race which requires diverse sets of gene pools. Finally, the argument continues that economic expansion cannot be controlled in a state, without measuring such activities as deforestation, mining despoliation, agricultural land decimation and comparing the land changes. All of these can be viewed through remote sensing without intruding upon native lands. Yet all of these reasons benefit not merely the indigenous Americans but also the rest of the human race. Thus benefits accrue but to whom?

Third party commercial and governmental entities who acquire this data and store the data in their databases without consent continue the commercial exploitation of information without compensating the very people whose data is being extracted. It is a decidedly western concept; akin to the missionaries viewing the natives and deciding that what's best for them; in tandem with the internal government i.e. extraction of the appropriate resources for the benefit of the dominant society.

Some European nations have decided that the remote satellite viewing is too intrusive and have begun making demands for the curtailment of the viewing.[74] I do not contend that we control the technology. Rather I contend that we control the behavior of those utilizing the technology.

Solutions must begin with the debate amongst academics, scholars, archaeologists, all who utilize the satellite imagery. The solution must also begin with the presence of the indigenous nations at the table of discussion. Any

[73] Walker n 8; Parcak n 2.
[74] Infra Lasaponar.

discipline that uses the aerial photography must begin the debates on privacy and consent. Without that resolution, the west is once again appropriating resources of the indigenous folk in the name of progress.

In addition, there must be a focus on the nation state itself where the indigenous people are located. States function as constantly evolving, and the governmental institutions themselves continue to reconstruct and evolve, responding to different events, eternal conflicts, opportunities and controls both within and across geographical boundaries (Klug 2011)[75]. Globalization and governance with the intersectional issue of territorial authority based on political and military authority and interdependence based on global competition and production may have a countervailing influence on attempts to regulate intellectual property norms on an international basis.[76]

A note of caution, in this debate concerning the appropriate use of Remote Sensing, the scientist must avoid characterizing and converting the argument about Remote Sensing of indigenous people into an argument concerning only the preservation of traditional cultural heritage.

That argument easily redounds into two approaches to regulating traditional culture within intellectual property law. Sean Pager characterizes these contrasting approaches as offering a choice between preservation and innovation (Pager 2012).[77] He posits that the preservationist wants to harness intellectual property rights to safeguard culture in authentic form. Whereas, he argues innovationists seek an approach which encourages tradition to evolve into new and adaptive forms of expression.[78] He cites various scholars such as Tom Greaves who 'locate the threat externally in the corrupting influence of global markets which commodifies cultural heritage, contaminates its source and distorts the

[75] Heinz Klug, Access to Medicines and the Transformation of the South African State; Exploring the Interactions of Legal and Policy changes In health, Intellectual Property, trade and Competition Law in the Context of South Africa's HIV?AIDS Pandemic, American Bar Association. Klug argues that the state responds to shifting opportunities and constraints, and different policies and competing political and economic factions' impact which rules are embraced, created, reshaped or ignored for and to the benefit of its people.
[76] Id at 299.
[77] Sean Pager, Folklore 2.0: preservation Through Innovation, 2012 Utah L.Rev. 1835.
[78] Id.

meaning of tradition which imperils the survival of the heritage and the people'.[79] Pager then cites Kwame Appiah, who 'locates the threat internally'. [80]Appiah, Pager believes celebrates and embraces change by the societies; arguing that failure to adapt to new circumstances invites extinction. Appiah also 'celebrates contamination as enriching cultural diversity, claiming that producers of traditional handicrafts benefit from increasing sales.'[81]

This approach places the issue of Remote Sensing of indigenous people in the middle of the argument for and against strong intellectual property rights. As Pager asserts, 'a strong property rights model assumes that culture is a fragile flower whose integrity must be zealously defended.[82]

However, this issue of satellite remote sensing implicates privacy concerns, international security issues, constitutional parameters as wells as ethical issues. For example, Google and the National Security Agency[83] have partnered allowing for the sharing of critical information. This pairing of the NSA with private companies in an information sharing, interdependent technology sector raises questions about the nations' infrastructure, transportation systems, communication networks and the national power grid. [84] Thus privacy rights and expectations of privacy become commingled with a governmental imperative in the use of remote sensing for viewing indigenous people as well as for the viewers who use this technology.

The issue for debate involves more than cultural preservation of traditional knowledge. The issue of concern is the ability of humans to control the technology utilized for academic, scientific, casual and observational purposes. As

[79] Id
[80] Id
[81] Id
[82] Id at 1894.
[83] The National Security Agency: NSA?CSS Mission, Nat'l Sec. Agency, http://www.nsa.gov/about/mission/indes.shtml ; a branch of the federal government established to provide protection for national security systems of the United States and to gather, collect and produce information about foreign intelligences. It uses the information to fight terrorism, protect military troops and provide for the national security.
[84] Stephanie A. Devos, The Google-NSA Alliance: Developing Cyber-security Policy at Internet Speed, 21 Fordham Intell. Prop. Media & Ent. L.J.173. FN 167, 168.

Jack Balkins asserts, the line between public and private modes of surveillance and security has blurred if not vanished. "Public and private enterprises are thoroughly intertwined. The NSA program would be impossible without the assistance of telecommunications companies; the government now requires that new communications technologies be designed with back ends that facilitate government surveillance."[85]

> Private power and public-private cooperation pose a third danger because the Constitution does not reach private parties, government has increasing incentives to rely on private enterprise to collect and generate information for it. Corporate business models, in turn, lead companies to amass and analyze more and more information about people in order to target new customers and reject undesirable ones. As computing power increases and storage costs decline, companies will seek to know more about their customers and sell this valuable information to other customers and the Government.[86]

In addressing the privacy, security, transparency and accountability concerns in the partnering of intelligence service information gathering of private authorities and government agencies, one author proposes the creation of a property right in personal information.[87] This protection should be coupled with a regulation on the access, transfer, use and retention of data. Requirements of technical safeguards and oversight structures such as reporting requirements, random audits, and re-visiting privacy laws on both the federal and state levels with a judicial clarification and re-structuring of privacy expectations is warranted.[88]

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[85] Jack M. Balkin the Constitution in the National Surveillance State, The Minnesota Law Review.

[86] Id at 17.

[87] See, Laura K. Donohue, Anglo American Privacy and Surveillance, 96 J.Crim. L. & Criminology 1059, "what makes the situation qualitatively different now is not just the lowering of the bar: digitization and the rapid advancement of technology mean that the type and volume of information currently available eclipses that of previous generations. And the issue is not confined to the United States."

[88] Id. In United States v. Jones, 132 S. Ct. 945, 949 (2012) the Court expanded its definition of a search (holding that the government's installation of a global positional system tracking device to a vehicle and the use of that

The ownership of one's lifestyle, habits, customs, social interactions, feeding mechanisms, familial relationships, spiritual connections, health information, and locomotion is a penumbra of privacy belonging to personhood.[89]

The digitized data acquired by satellite remote viewing of indigenous people without their consent or adherence to privacy protocols is dangerous and subject to capitalistic exploitation. The model assumes ownership of this digitized data belongs to the corporate satellite entity for sale as property. Satellite Remote viewing of indigenous societies without protections expands western colonial dominance actions of historical exploitation. Even in the face of use by academicians and scholars the use of this data without oversight, protections, consent and human study protocols is alarming. Perhaps the nation state grants permission but the development of ethical standards by scholars and academicians must occur.

CONCLUSION

Remote Satellite Sensing is simply another form of modern technology. Much like the broom in the folktale, the Sorcerer's Apprentice, the technology created by humans and our behavior must be directed or we risk losing control.[90]

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device for over a month to monitor the vehicle's movements, constitutes a search under the Fourth Amendment). However, the Court failed to clearly articulate a precise standard for the technology in use by refusing to identify when the government conditions people to have 'no expectation of privacy' will the Court modify its search test.

[89] William Prosser, 48 Cal. L. Rev. 383(1960), described an analytical framework for privacy, recognized in the Restatement of Torts which still resonates today: (1) intrusion upon seclusion, (2) public disclosure of private facts, (3) false light and (4) appropriation. Although the privacy right first articulated by Samuel Warren & Louis Brandeis, in The Right to Privacy, 4 Harv. L. Rev. 193 (1890), it rejected property rights and copyright as a tool to protect privacy. In Katz v. United States, the Supreme Court defined a search (and intrusion without a warrant based on probable cause or exigent circumstances) pursuant to the Fourth Amendment of the U.S. Constitution as a government examination of an area in which a person has a 'reasonable expectation of privacy.' In Katz, 389 U.S. at 361, the Court described the test for a governmental violation of the Fourth Amendment as consisting of a 'twofold requirement, first that a person have exhibited an actual (subjective) expectation of privacy, and second, that the expectation be one that society is prepared to recognize as 'reasonable."

[90] The satellite remote sensing coupled with the increasing ability of private corporate companies to amass immense volumes of data and the acquisition and storage of information obtained from that data; then utilized on the population to sell, service, deny, spy, and manipulate behavior is tantamount to 'magic' going amok.

Indigenous people are not rats in a maze or bacteria in a Petri dish waiting for manipulation, observation and experimental control by those who wish to advance the frontiers of science, anthropology, climate control, bio-diversity, or continuation of the gene pool. They own their lives. If one must utilize a humanistic animal analogy, one could perhaps liken un-contacted societies, viewed through a private satellite company with governmental partners, to canaries in the miners' cave. Methods of insufficient governance, neglected constitutional values, inadequate intellectual property concerns and unethical behaviors may occur at the hands of the willing populace in the calculated voyeurism of an indigenous people only to rebound and suffocate us while we sleep.

Google Earth™

Description	*A virtual 3D globe with imagery and topographic data from multiple satellite image types, aerial photographs, and the Shuttle Radar Topography Mission*
Accessibility	http://earth.google.com/
Advantages	free; available 24 hours a day; global coverage; accessible from Mac or PC; easy to use; can upload photos or points; can view 3D landscapes
Disadvantages	non-global, high-resolution coverage, some areas have 30 m resolution coverage; limited 3D coverage of landscapes; difficult to see sites in dense canopy
Features	can view entire archaeological sites, buried walls, and architecture, can view old river courses in desert locations, etc.; users can upload photographs of sites and features
Resolution	.6m–.30m
Cost	Free, except for certain features

NASA WorldWind

Description	*An online global imagery viewing program, created and run by NASA, with many similarities to Google Earth™. The biggest difference is that the full version of World Wind is entirely free. Released in 2004, individuals can view not only the Earth, but can also view satellite imagery of the Moon, Mars, Venus, Jupiter, stars and galaxy.*
Accessibility	http://WorldWind.arc.nasa.gov/
Advantages	free; available 24 hours a day; global coverage; accessible from PC, Mac, or Linux; easy to use; can upload photos, points, or GIS data; can view 3D landscapes
Disadvantages	non-global, high-resolution coverage, some areas have 15–30 m resolution coverage; do not know exact time or date of imagery
Features	can view entire archaeological sites; can see buried walls or architecture and old river courses in desert locations; can see landscape changes over time, including vegetation changes
Resolution	1–30 m
Cost	free

Corona High Resolution Space Photography/KH-7/KH-9

Description	Corona high-resolution satellite photography is imagery that has become quite valuable to archaeologists, due to its high resolution, low cost, ease to obtain, and its value in recording landscapes now built over or destroyed.
Accessibility	http://www.usgs.gov
Advantages	preserves views of many vanished landscapes; high resolution; inexpensive; fairly straightforward use; global coverage; viewable on any image viewing program
Disadvantages	imagery can be grainy; image distortion; need negatives for best resolution; non-multispectral; need to georeference; sometimes memory intensive
Features	can view entire archaeological sites, buried walls and architecture, vanished landscapes and associated environmental features
Resolution	6–150 m
Cost	US$30 per scanned negative
Airphoto	http://www.uni-koeln.de/~al001/airphoto.html

Landsat

Description	Landsat imagery, first recorded in 1972, has had the broadest usage in archaeology of all the types of satellite imagery. This is due to its low cost, worldwide coverage, and the numerous techniques one can apply with it. Landsat imagery is most versatile in diverse landscape conditions because of varying band lengths in the electromagnetic spectrum.
Accessibility	http://www.landsat.org (click on "search for imagery" to access free data) http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp
Advantages	global coverage from 1972–present; multispectral; can analyze a wide range of landscape types
Disadvantages	non-high-resolution banding on imagery from 2003–present; requires knowledge of remote sensing analysis; need remote sensing programs for multispectral use
Features	mutispectral data highlights vegetation, soil and geological features associated with past remains; shows how remains can be viewed in seven bands of the EM spectrum
Resolution	15–80 m
Cost	free–US$600

SPOT

Description	SPOT, or System Pour L'Observation de Terre, launched in 1978 by the French government, is utilized in all areas of scientific research, and is especially well suited for mapping and producing digital elevation models through stereo pairs.
Accessibility	http://www.spot.com/web/SICORP/425-sicorp-price-list.php; http://www.americaview.org/
Advantages	global coverage from 1978–present; multispectral; can analyze wide range of landscape types
Disadvantages	requires knowledge of remote sensing analysis; need remote sensing programs for multispectral use
Features	suitable for detecting vegetation changes associated with archaeological sites; panchromatic data can detect smaller architectural features
Resolution	0.8 m (panchromatic), 5–20 m (multispectral)
Cost	: US$1200 (normal scene, 5 m panchromatic, 20 × 20 km, or 1/8th scene); US$11,750 (orthorectified 2.5 m color merge, 60 × 60 km, full scene), see pricing list on the website above; 35–85 percent discount for academic researchers throughthe AmericaView program.

ASTER

Description	Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), costsUS$80 per scene, including free digital elevation models, with scanners in the visible,near-mid and thermal IR portions of the electromagnetic spectrum. This system is particularly useful for digital elevation models, which the original data can be draped over to create 3D imagery.
Accessibility	http://glovis.usgs.gov/
Advantages	most of the globe is covered; hyperspectral; can analyze a wide range of landscape types
Disadvantages	requires knowledge of remote sensing analysis; need remote sensing programs for multispectral interpretation
Features	hyperspectral data allows more detailed mutispectral analysis
Resolution	15–90 m
Cost	US$80 per scene, free if a NASA partner

SRTM

Description	The SRTM (Shuttle Radar Topography Mission) provides 3D global elevation data without charge to any user.
Accessibility	http://www.jpl.nasa.gov/srtm/cbanddataproducts.html; http://edc.usgs.gov/products/elevation.html; http://seamless.usgs.gov/; http://glcf.umiacs.umd.edu/data/srtm/index.shtml; http://srtm.csi.cgiar.org/
Advantages	free; available 24 hours a day; global coverage; accessible from Mac or PC; easy to use; can download in multiple formats
Disadvantages	limited, high-resolution coverage; some areas have 30 m resolution coverage, some imagery is more detailed than others
Features	can view landscapes in 3D; can drape other satellite imagery on top of SRTM
Resolution	1–90 m
Cost	free

High resolution imagery: Quickbird and IKONOS

Description	global coverage; multispectral
Accessibility	http://www.digitalglobe.com; http://www.satimagingcorp.com/; http://www.geoeye.com/CorpSite/
Advantages	
Disadvantages	high cost; need remote sensing programs for multispectral use
Features	both images can detect buried walls, archaeological sites, and aid in detailed mapmaking; locate vegetation associated with archaeological sites and features
Resolution	0.6–3.2 m (Quickbird 0.6–2.4 m and 0.82–3.2 m IKONOS)
Cost	Quickbird costs US$10–28 per km2 with additional costs if imagery is express ordered; IKONOS costs US$7.70 per km2, or orthorectified at US$13.20 per km2

RADAR (SIR-A, SIR-B, SIR-C, X-SAR)

Description	Radar imagery is used to detect a wide range of sites and features ranging from natural to human-made, including trails, roads, and canals.
Accessibility	http://www.jpl.nasa.gov/radar/sircxsar/; http://www.dlr.de/caf/en/desktopdefault.aspx
Advantages	near global coverage; can see beneath sand and rainforest canopy
Disadvantages	need remote sensing programs for multispectral use; difficult to open
Features	buried features (roads, rivers) can have associated archaeological remains alongside or near them
Resolution	15–45 m
Cost	SIR-C US$50 (three scenes); X-SAR US$40 per scene

LIDAR

Description	LIDAR (for LIght Detection And Ranging) provides high resolution detail on features beneath the ground. The detail provided by such images is unparalleled and will open up many new avenues for archaeological research, perhaps allowing for detailed mapping that, until this point, has been limited to aerial photographs, ground penetrating
Accessibility	http://www.geoeye.com/CorpSite/products/products/mjharden/lidar.aspx (US projects); http://www.lidar.co.uk/ or http://www.geomatics-group.co.uk/lidar.html?lang=_e (UK/European projects)
Advantages	can view subtle landscape changes; high-resolution feature detection
Disadvantages	high cost; not possible to fly everywhere in the world
Features	can detect field patterns, architecture and other archaeological features not visible on aerial photographs; very high resolution data can detect features not visible on other satellite images
Resolution	3 cm
Cost	depends on project

Other airborne sensors: RADARSAT, airborne thermal radiometry

Description	RADARSAT and AIRSAR are SAR (Synthetic Aperture Radar) satellites, both with similar capabilities. RADARSAT is a commercial satellite controlled by the Canadian Space Agency, while AIRSAR belongs to NASA.
Accessibility	http://www.space.gc.ca/asc/eng/satellites/radarsat1/; http://gs.mdacorporation.com/products/sensor/radarsat/rs1_price_ca.asp
Advantages	can see beneath cloud cover and vegetation
Disadvantages	high cost, limited global data
Features	possible to identify roads, pathways, and entire sites in rainforest areas
Resolution	3 m (RADARSAT-2), 8–30 m (RADARSAT-1); 2.4–13.7 m (SAR)
Cost	RADARSAT-1 Archived imagery US$1500; other imagery US$3600–4500; RADARSAT-2 depends on scene size, higher cost for additional processing and rush orders; ATR depends on scene size, must be worked out with NASA

See also, Sara Parcak, Satellite Remote Sensing Imagery for Archaeology