Technical Capabilities of Remote Sensing Satellites: The Potential for Human Scale Development or Abuse

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This paper will reflect on the technical capabilities of remote sensing satellites to deliver satellite imagery, in either spatial, spectral, or temporal resolution, which may in practice or in future be abused.
This paper will provide a human capacity framework against which the utilisation and impact of remote sensing satellites will be evaluated. This will be done in order to illustrate the technical capabilities of remote sensing satellites in the context of a value system.
This paper will predominantly focus on what can be detected, recognised and identified through the use of remote sensing. A number of examples will provide a basis for the understanding of what can be detected from Space.
For many decades, the driving force in the realm of remote sensing satellites has been ground resolution. However, as a result of technology advances and the miniturisation of electronics and detectors, multiple spectral bands can now be detected. For example, radar enabled satellites have the capability to provide all weather and day/night coverage. Additionally, these advances in satellite technology have also increased coverage as a result of lower cost per individual satellite in a constellation. Examples of this include Skybox, Planet-Labs and GSOUC.
Through the initially review of what can be detected, recognised and identified from Space, this paper will then reflect on the impact of remote sensing on human scale development, concluding with inputs to policy guidelines for regulating remote sensing for the benefit of mankind.

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I. Introduction

"Un croquis vaut mieux qu"un long discours" translated means, a picture is worth a thousand words[1]. First uttered by Napoleon, it is only now, almost two centuries later that images truly have the capacity to encompass and convey increasingly complex information.

In the last decade, increasing advances in Space technology has continued to drive the diversification in the application of satellite imagery. At present, remote sensing satellite imagery is utilised across a myriad of diverse industries and government departments, largely to the benefit of the respective indigenous societies. Just some of these sectors include mining, oil and gas, engineering and construction, defence and security, environmental monitoring, natural resource management such as agriculture and forestry, and tourism[2].

However, despite illustrating a predominantly positive impact through application linked to issues such as economic development and human security, the possible abuses of satellite imagery cannot remain unaddressed.

This paper will therefore look at the topic of remote sensing satellite imagery holistically; establishing technical capabilities, illustrating both the positive and negative application of satellite imagery, and then addressing possible risks and necessary policy guidelines.

II. Remote Sensing Capability

The three major characteristics of remote sensing data are:

a. Spatial information
b. Spectral information
c. Temporal information

An example of each characteristic is given below.

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1 Suárez, J. C. n.d. *The Use of Remote Sensing Techniques in Operational Forestry*. [Online]. Available: http://www.forestry.gov.uk/pdf/QJFarticle.pdf/$FILE/QJFarticle.pdf. [2014, September 8].

2 Satellite Imaging Corporation. 2001. *Satellite Images for Environmental Monitoring*. [Online]. Available: http://www.satimagingcorp.com/applications/environmental-impact-studies/. [2014, September 9].

Spatial Resolution

The impact of spatial resolution can be seen in a comparison of the same scene with a 10m ground resolution and a 1m ground resolution. This example makes it clear that 1m ground resolution is good for making observations of the built environment.

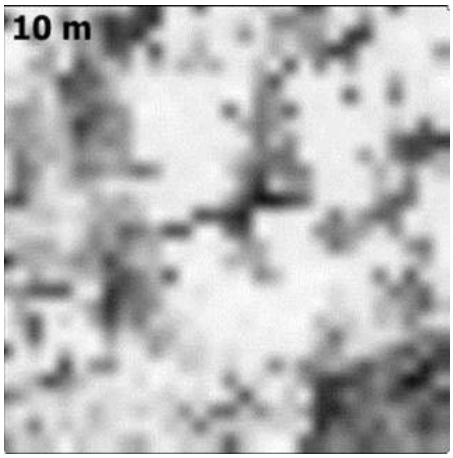

Figure 1 A scene in 10 m ground resolution

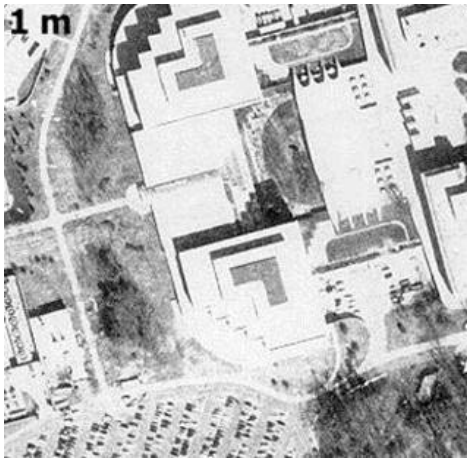

Figure 2 A scene in 1 m ground resolution

Spectral Resolution

Subheadings are underlined and placed flush on the left hand margin of the column.

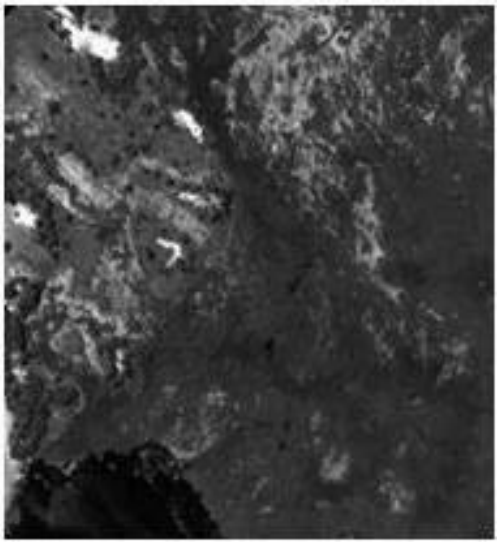

Figure 3 A scene from the Okavango Delta in Blue, Green and Red

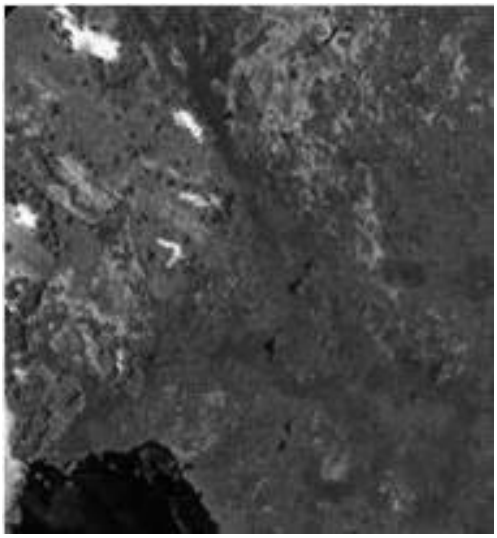

Figure 4 The same scene from the Okavango Delta in Green, Red and Near-InfraRed

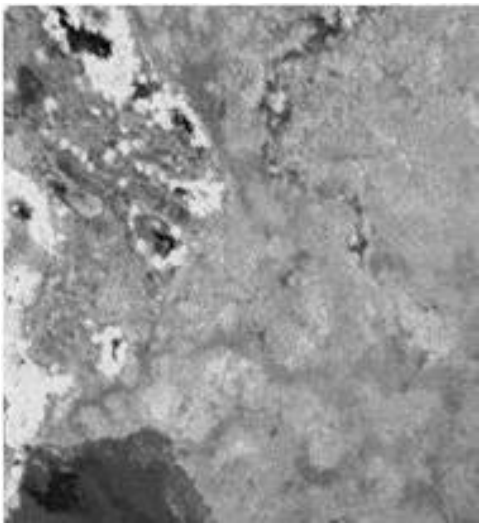

Figure 5 The same scene from the Okavango Delta in 100 colours (Hyperspectral observation

Temporal Resolution

Temporal resolution allows one to compare and observation on one date with another. With multi-year observations a time series can also be constructed.

Figure 6 A scene from Google Earth of a famous harbour on 18 Sep 2010.

Figure 7 A scene from Google Earth of the same famous harbour sometime in 2012.

From the examples it should be clear that a large amount of information can be collected from space. The question is however, what is it used for?

III. Utilisation of Remote Sensing

The rising sophistication of Space EO data has raised many fears within the international community of current and future abuses of such data should regulation remain limited. With regards to EO data, this council itself has identified some threats of abuse in areas of privacy, human rights and public order (terrorism).

However, while most technologies have the potential for dual usage, it is important to highlight how this data also has the immense potential to facilitate human security and economic development, while also counteracting some of above identified threats. In Resolution 66/290 on human security, the General Assembly agreed to a definition which included;

(a) "The right of people to live in freedom and dignity, free from poverty and despair… [and] with an equal opportunity to enjoy all their rights and fully develop their human potential;

(b) Human security calls for people-centred, comprehensive, context-specific and prevention- oriented responses that strengthen the protection and empowerment of all people and all communities;

(c) Human security recognizes the inter-linkages between peace, development and human rights"[3].

[3] United Nations General Assembly. 2012. "66/290. Follow-up to paragraph 143 on human security of the 2005
World Summit Outcome" in the *Resolution adopted by the General Assembly on 10 September 2012*. Sixty-six session.

Additionally, the issue of development remains key to the mandate of councils such as the United Nations Economic and Social Council (Development Cooperation Forum)[4] and the United Nations Development Programme[5]. Thus, it is important to recognise that the EO data generated via remote sensing satellites provide objective data sources and a valuable source of information for decision makers[6].

Information that, within the framework of human security and development, empowers local and international decision makers to make more informed decisions with regards to questions on security, human rights and good governance, resources and the environment, along with health and development[7]. This section will thus serve to illustrate the largely positive application of EO data.

Monitoring Purposes

Outside of a security application (an aspect of human security) which includes examples such as border monitoring, EO data has also been applied to areas such as deforestation, desertification, coral reef and vegetation classification and mapping, pollution tracking and prevention, forest fires detection, agricultural production, co-seismic displacement, resource and flood monitoring, and weather devastation observation. These are important applications given the current strain placed on our environment by the effects of climate change and overpopulation which threaten development efforts and human security.

The importance of this EO data lies in examples such as the Huong Son, a tropical forest situated in Vietnam. With an economy centred on timber, unsustainable logging practices now threaten this economy with both deforestation, but also the added repercussions of forest carbon sequestration and soil erosion for example[8]. However, if utilised correctly, EO data can facilitate proper forest management and an ecosystem service assessment. Thus

4 United Nations Economic and Social Council. 2014. *Mandate of the DCF*. [Online]. Available: http://www.un.org/en/ecosoc/newfunct/mandate.shtml. [2014, September 23].

5 United Nations Development Programme. 2013. *UNDP's Mandate*. [Online]. Available: http://www.undp.org/content/undp/en/home/mdgoverview/mdg_goals/progress/. [2014, September 23].

6 Joyce, K., Wright, K., Ambrosia, V. & Samsonov, S. 2010. "Incorporating Remote Sensing into Emergency Management", in *the Australian Journal of Emergency Management*, vol. 25, no. 4.

7 Human Security Initiative. 2011. *Definition of Human Security*. [Online]. Available: http://www.humansecurityinitiative.org/definition-human-security. [2014, September 7].

8 ESA.n.d. *Observing the Earth*. [Online].Available: http://www.esa.int/Our_Activities/Observing_the_Earth/Space_for_nature. [2014, September 8].

ensuring both human security through a sustained economy, and industry development through the improved targeting of high profit areas.
Additionally, given that most of the world"s population today live in urban areas, it is important to note that urban and land development and monitoring frequently utilise EO data to improve decision making. For example, EO data can assist a government and its local municipalities with gauging population density, this can in turn be utilised to make service delivery more effective. EO data is also frequently utilised in the evaluation of "construction costs, land cover and land use classification, and importantly, the identification of population groups at risk (areas where human intervention is most needed to limit and prevent hazards during development stages and more)"[9].

Disaster Management

Over the past four decades, "economic losses due to natural disasters have shown an increase with a factor of eight" as a result of both an increase in weather related disasters and vulnerability of the international community[10]. Developing States, as a result of the intensity and frequency of natural and man-made disasters and their "disproportionately high economic, social and environmental consequences", are especially vulnerable[11].
However, EO data can be an effective tool for disaster management as it can be utilised for prevention, preparedness, relief, and reconstruction, providing information for large areas at short time intervals[12]. Remote sensing is currently actively being utilised in the disaster preparedness and warning phases for cyclones, droughts and floods[13]. Thus, EO data utilised in this capacity, facilitates prevention-oriented responses and mitigation with regards to the protection of potentially affected communities, and thus human security against climate based and man-made disasters.

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[9] Satellite Imaging Corporation. 2001. *Satellite Images for Environmental Monitoring*. [Online]. Available: http://www.satimagingcorp.com/applications/environmental-impact-studies/. [2014, September 9].

[10] Van Westen, C. J. 2000. "Remote Sensing for Natural Disaster Management", in *International Archives of Photogrammetry and Remote Sensing*, vol. XXXIII, Part B7. Amsterdam.

[11] Van Westen, C. J. 2000. "Remote Sensing for Natural Disaster Management", in *International Archives of Photogrammetry and Remote Sensing*, vol. XXXIII, Part B7. Amsterdam.

[12] Van Westen, C. J. 2000. "Remote Sensing for Natural Disaster Management", in *International Archives of Photogrammetry and Remote Sensing*, vol. XXXIII, Part B7. Amsterdam.

[13] Sulik, J. J. & Edwards, S. 2010. "Feature extraction for Darfur: geospatial applications in the documentation of human rights abuses", in the *International Journal of Remote Sensing*, vol. 31, no. 10. 2521.

Natural	Some Human Influence	Mixed natural/ human influence	Some natural influence	Human
Earthquake	Flood	Landslides	Crop disease	Armed conflict
Tsunami	Dust storm	Subsidence	Insect infestation	Land mines
Volcanic eruption	Drought	Erosion	Forest fire	Major (air-, sea-, land-) traffic accidents
Snow storm/avalanche		Desertification	Mangrove decline	Nuclear/chemical accidents
Glacial lake outburst		Coal fires	Coral reef decline	Oil spill
Lightning		Coastal erosion	Acid rain	Water/soil/air pollution
Windstorm		Greenhouse effect	Ozone depletion	Groundwater pollution
Thunderstorm		Sealevel rise		Electrical power breakdown
Hailstorm Tornado				Pesticides
Cyclone/ Hurricane				
Asteriod impact				
Aurora borealis				

Table 1 Van Westen, C. J. 2000. "Remote Sensing for Natural Disaster Management", in *International Archives of Photogrammetry and Remote Sensing*, vol. XXXIII, Part B7. Pg. 1610. Amsterdam.

Human Rights Abuses

Interesting to note, despite being identified as a possible tool aiding in/ facilitating human rights abuses, advocates are increasingly utilising EO data to monitor human rights abuses[14]. This is made possible as a result of the increasing sophistication of EO data and its high-resolution image analysis. Agencies such as the AAAS have provided, on an ad-hoc basis, EO data analysis for use in human rights litigation.

To date, this has included "the conflict in South Ossetia, Georgia (European Court of Human Rights), forced evictions in Zimbabwe (African Commission and the African Court of Human and Peoples" Rights), and mass human rights violations in Darfur (International Criminal Court)" [15]. Additionally, in countries like Sudan, the Satellite Sentinel Project is utilising EO data to both identify potential threats to the local population and to document cases of crimes against humanity[16].Thus, EO data can be effectively utilised to monitor the human security situation in volatile areas.

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[14] American Association for the Advancement of Science. 2013. *Remote Sensing for Human Rights Project*. [Online]. Available: http://www.aaas.org/page/remote-sensing-human-rights-project. [2014, September 9].

[15] Satellite Sentinel Project. 2014. *Our Story*. [Online]. Available: http://www.satsentinel.org/our-story. [2014, September 24].

[16] American Association for the Advancement of Science. 2013. *Remote Sensing for Human Rights Project*. [Online]. Available: http://www.aaas.org/page/remote-sensing-human-rights-project. [2014, September 9].

However, human rights abuses are not just related to conflict scenarios, but rather to the more central issue of human security. EO data generated for the purposes of agricultural management, mining or volcanology for example, while diverse, all have valuable human rights applications[17]. The Moderate Resolution Imaging Spectroradiometer for example was used to document the ongoing gas flaring in the Niger Delta, despite a 2008 moratorium[18]. Thus, illustrating that EO data can
play an important role in international oversight, keeping both governments and non-governmental actors accountable.

IV. Possible Abuse of Remote Sensing

Despite all the benefits of EO data, there is also the reality that the precursors for the modern remote sensing system, was based on the World War I military application which saw cameras mounted onto aeroplanes for military reconnaissance[19]. Since then, private industry has increasingly driven the commercialisation of remote sensing and EO data application. However, this does diminish the possible dual usage of EO data and its potential and future abuses.
For example, the expanded spectral range of high resolution sensors now allow for a more "accurate identification of on-the-ground features"[20]. While this improved sophistication of remote sensing and EO data is currently being utilised positively in countries like to Darfur to monitor civil war and possible human rights abuses, there is also the possibility that, in the hands of terrorist organisations or rouge governments, this technology may be utilised to target civilian groupings.
Additionally, the sovereignty of a nation is also being somewhat diminished given the limited control held by a country with regards to the level of which they are being „sensed", both by other countries but also increasingly, by non-governmental entities. There is also the reality that some countries, those on the lower rungs of the Space technology ladder, are forced to depend on external actors for necessary EO data. These factors have implications for both the security and privacy.

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[17] American Association for the Advancement of Science. 2013. *Remote Sensing for Human Rights Project*. [Online]. Available: http://www.aaas.org/page/remote-sensing-human-rights-project. [2014, September 9].

[18] Graham, S. 1999. *Remote Sensing: Introduction and History*. [Online]. Available: http://earthobservatory.nasa.gov/Features/RemoteSensing/. [2014, September 24].

[19] American Association for the Advancement of Science. 2013. *Remote Sensing for Human Rights Project*. [Online]. Available: http://www.aaas.org/page/remote-sensing-human-rights-project. [2014, September 9].

[20] American Association for the Advancement of Science. 2013. *Remote Sensing for Human Rights Project*. [Online]. Available: http://www.aaas.org/page/remote-sensing-human-rights-project. [2014, September 9].

At an individual level, the possible abuse of remote sensing data can be viewed from the perspective of keeping human needs from being satisfied[21]. The following table gives a summary of the various needs, and how remote sensing could possibly be abused in each case by denying the need to be satisfied.

Primary Needs	Having (things)	Possible Abuse
Subsistence	food, shelter, work	Denying jobs, access to food and shelter
Protection	social security, health systems, rights, family, work	Increasing risk to personal safety
Affection	friendship, family, relationships with nature	Privacy abuse
Understanding	literature, teachers, educational and	Not making information available
Participation	responsibilities, duties, work, rights, privileges	Denying rights
Idleness	games, parties, spectacles, clubs, peace of mind	Threatening peace of mind
Creation	skills, work, abilities, method, techniques	Denying jobs
Identity	symbols, language, religion, values, work, customs, norms,	Threatening identity
Freedom	equal rights	Threatening rights

Table 2 Fundamental Needs, their satisfiers from a Having perspective and possible abuse through use of Remote Sensing information.

V. Risk Assessment and Recommendations

As a result of the dual usage potential of EO data, there is an aspect of risk in its current and future application. In this context, it becomes vital to understand the full spectrum of potentially harmful EO data usage. Prevailing uncertainty can only be lessened once the holistic picture of the situation is understood, and all the possible risks can now be observed, measured, managed and where possible, avoided[22].

However, the difficulty with EO data usage lies in the fact that the data used to secure the national security of one country (viewed positively), may be seen as an infringement on the privacy of another and a threat to their national security (viewed negatively). While the data utilised to monitor the human security of a civilian population in a country with possible human

[21] Brink, C. H. 2004. *Measuring Political Risk: Risks to Foreign Investment*. England: Ashgate Publishing Company.

[22] Smith, P.B. and Max-Neef, M. 2011. *Economics Unmasked,*. England: Green Books,

rights abuses (viewed positively), can also be seen by the country in question as an infringement on their sovereignty (viewed negatively).
Thus, limiting the possible risks of EO data become difficult, as countries may vary on their understanding of when this data is being abused (used negatively). This is problematic as, unlike airspace, outer space does not fall into the jurisdiction of any one country or countries. Thus, along with knowing the possible risks associated with the harmful usage of EO data, the limitation of potential abuses of EO data will need to be driven by international policy.
Therefore, reaching an international consensus on what defines an abuse of this technology becomes critical to the creation of a successful policy. A policy which is too broad and which does not factor in these nuances will be rendered largely ineffective.

VI. Conclusion

This paper reviewed some of the parameters that can be observed from satellites and reflects on the possible abuse of such data.
Practical examples of the parameters of spatial resolution, spectral resolution and temporal resolution were provided. The different resolutions give an indication of the kind of information that can be derived from remote sensing data.
The paper then continues to reflect on the possible use and abuse of remote sensing data and comes to the conclusion that it depends on the perspective of the user of the data whether it constitutes abuse or use.
The resulting recommendation is that international regulation of some of the utilisation categories is required to avoid abuse of remotely sensed data.
Open questions arise out of the use of remote sensing data as part of Big Data processing, comparing it with models of expected behaviour and the use of data from Unmanned Aerial Vehicles (UAVs).