Making discoveries in virtual worlds via the Cloud

Analysts at Stanford University's Center for International Security and Cooperation (CISAC) http://cisac.stanford.edu/ together with colleagues at the James Martin Center for Nonproliferation Studies, Monterey Institute of International Studies (MIIS), are playing a leading role in deriving new, timely, and value-added information of global security and earth science relevance from a variety of open-source geospatial tools that include digital virtual globes like Google Earth together with satellite imagery available from commercial vendors via the internet Cloud. This article provides some discovery exemplars, by CISAC researchers and others, which have only quite recently become possible through the use of such tools.

Although Socrates, nearly 2400 years ago, is quoted as having said, "Man must rise above the Earth — to the top of the atmosphere and beyond — for only thus will he fully understand the world in which he lives,"[1] the actual capability of anyone (besides lunar astronauts) having the entire world in view from high above, if only virtually, was previously limited to either Science Fiction or Fantasy novels (e.g., "palantír", or the "all-seeing eye"). It was not until just before the turn of this millennium that there was serious discussion of being able to synoptically view multi-resolution, three-dimensional, virtual representations of the earth based upon imagery from commercial space-based satellite remote sensing systems that would offer the potential to make such global understanding possible (as even Socrates could never imagine).[2]

What had then only been a dream shortly became a reality with the advent of such democratizing digital geospatial applications (aka "Apps") as Google Earth.[*] That reality, and with it a new era of global transparency[3], was the product of the synergy made possible only by the confluence of the rapidly evolving computer and communications technologies combined with now ubiquitous high resolution (<one meter) imagery from an ever growing constellation of commercial imaging satellites[4]. The result is that now, anyone having computer access can instantly travel, virtually, from a vantage point of an entirely global view from space down to any point on the globe for a bird's eye view, without being subject to any physical, temporal, or political boundaries; while also being able to peruse both recent and historical imagery archives of that chosen area for subsequent investigation. Moreover, in addition to built-in historical archive layers viewable with some virtual globes, commercial satellite imagery vendors such as DigitalGlobe have established internet accessible "Cloud services" that allow clients to instantly access their entire libraries of high-resolution imagery from desktops, laptops, and mobile devices around the world, and in formats that can be easily overlain and viewed on digital virtual globes like Google Earth.

· Beginning in 2002 with Keyhole's Earth Viewer http://en.wikipedia.org/wiki/Keyhole,_Inc , that in 2005 became Google Earth http://www.google.com/earth/, which recently surpassed 1.2 billion downloads. See also, NASA's WorldWind, http://www.worldwindcentral.com; Nokia Maps 3D, http://maps.nokia.com/3D; Skyline Globe, http://www.skylineglobe.com/SkylineGlobe/; FlashEarth, www.flashearth.com/; etc.

Such virtual globes also promote global transparency by providing a new, essentially free, means to conduct broad area baseline search either alone, or with tip-off via open source leads; identified on internet Blogs and Wiki layers with input from a "free" cadre of global browsers and/or by knowledgeable local citizens (a.k.a., "crowdsourcing"[5]) that can include ground photos and maps; or by other initiatives based on existing country program knowledge accessible via non-centralized global databases of geo-referenced information. The virtual globes also provide highly accurate terrain mapping for better overall geospatial context and allow detailed 3-D perspectives of all sites or areas of interest, whether for the remote monitoring of facilities or for more accurate reconnaissance geologic mapping. 3-D modeling software (e.g., Trimble's SketchUp http://www.sketchup.com/) when used in conjunction with these virtual globes can significantly enhance individual building characterization and visualization (including interiors). These new geospatial tools also now make it possible for anyone to conduct his or her own satellite-based reconnaissance for any application from the comfort of home, or at any WI-FI enabled coffee shop...and a lot of it can be done with just a smart phone. Among the myriad science focused discoveries using these tools include the identification of a recent, but previously unknown, meteor crater in Egypt[6]; ancient fortresses from lost civilizations in southern Libya[7]; previously unknown and un-contacted tribes in the Brazilian rain forest[8]; and predator/prey boundaries along the Great Barrier Reef[9].

Global Security Exemplars

With respect to global security applications, that capability has made possible a host of investigations resulting in somewhat surprising discoveries found in otherwise denied environments; and which would have been impossible for anyone not previously having the resources of at least a super-power nation state. It should be noted that others, such as Vipin Gupta (currently at Sandia National Laboratory), had previously foreseen such developments over two decades ago and were pioneers in adapting commercial satellite imagery for treaty verification applications[10]. Other leaders in the field who are currently posting on their own global security relevant blogs include, David Albright, http://www.isis-online.org/; Jeffrey Lewis, http://armscontrolwonk.com/; Joel Wit, http://38north.org/; Hans Kristensen, http://www.fas.org/blog/ssp/category/hans_kristensen; Sean O'Conner, http://geimint.blogspot.com/; and Stefan Geens, http://ogleearth.com/. For other global security applications, such as IAEA safeguards monitoring[11], foreign conflict monitoring[12], environmental monitoring[13], and disaster assessment[14]; International Agencies and Non-Governmental Organizations (NGOs) are becoming increasingly active and adept in their use of such a capability. Actor George Clooney's Satellite Sentinel Project is currently fusing commercial satellite imagery with crowdsourced "analysis and advocacy" in an effort to "end genocide and crimes against humanity" in Southern Sudan.[15]

Nick Hansen, an Affiliate researcher with CISAC, using commercial satellite imagery of the Iranian missile and space launch complex at Semnan, Iran, was able to detect evidence of failed space launches of the Fajr satellite in May 2012, and again more dramatically in late September 2012 that went entirely unreported by the Iranian Government, the Iranian media, and the international media.[16] Another CISAC Affiliate, Allison Puccioni, has recently been reporting on the latest developments at the Yongbyon Nuclear Research Center for IHS Jane's Defence Weekly[17]. Similarly, on the basis of a cue from Jeffrey Lewis, another CISAC Affiliate and Professor at MIIS[18], it was possible for CISAC Affiliate Frank Pabian to use Google Earth to precisely locate North Korea's reported "Strategic Rocket Forces Headquarters." Moreover, confirmation of that location was made possible through correlation of outdoor ground images of the North Korean leader, Kim Jong Un, with what could be determined using Google Earth (see Figures 1-3). Other recent unclassifed work involving such geospatial tools includes: determining the precise location of the epicenter's of North Korea's 2006 and 2009 underground nuclear tests[19], and creating 3-D models of North Korea's new experimental light water reactor and its 2000 gas centrifuge uranium enrichment cascade hall (including interiors based on the 2010 visit to North Korea by former Los Alamos National Laboratory Director, Seigfried Hecker[20]).

As of this writing, the world has just witnessed a third underground nuclear test by North Korea, and is poised for additional testing, under the rubrick of a resumption of nuclear weapons testing at a "higher level" than the two previous tests. However, because of the now near ubiquitous availability (via the internet Cloud) of high resolution commercial satellite imagery (sometimes multiple images daily) and its analysis being posted worldwide, anyone can now comfortably peer over the fence to monitor ongoing activities in denied areas such as that now being undertaken at North Korea's nuclear test site, and even do so from a three dimensional ground-level perspective using Google Earth (see Figure 4)[21]. Global transparency has become the new reality. Virtual worlds and access to the internet Cloud have made possible significant discoveries in both science and global security (that were previously impossible) for any motivated individual simply having an interest in making them.

Figure 1: Following the footsteps of Kim Jong Un at the North Korean "Strategic Rocket Forces Headquarters" on Google Earth (ground photos from http://www.youtube.com/watch?v=cRoqltJLl6c)

Figure 2: North Korean leader, Kim Jong Un (seated), being shown an historical satellite image from ~2005 on a large flat screen computer monitor in the "Training Center" at the "Strategic Rocket Forces Headquarters" according to North Korean National Television, KCNA (Source Date 2 March 2012) http://www.youtube.com/watch?v=cRoqltJLl6c (4:32)

Figure 3: Comparison of the computer monitor screen view (upper left) with a Google Earth image (tinted blue for better correlation) of the area that North Korean National Television identified as being the "Strategic Rocket Forces Headquarters."

Figure 4: Peering over the fence at the North Korean Nuclear Test Site in 3D perspective using Google Earth and SketchUp modeling (circa 2010), looking north past the Main Support Area towards the "West" Tunnel Portal that was evidently used to conduct both the 25 May 2009 and 12 February 2013 underground nuclear tests.[22]

References

[1] Mark E. Brender, "Don't Pull the Rug out Now," *Space News*, 25 April 2012. http://www.spacenews.com/article/dont-pull-rug-out-now#.UQbc-b9EFCw

[2] Al Gore, "The Digital Earth: Understanding our planet in the 21st Century," Given at the California Science Center, Los Angeles, California, on January 31, 1998. See also, M. Craglia, K. de Bie, D. Jackson, M. Pesaresi, G. Remetey-Fülöpp, C. Wang, A. Annoni, L. Bian, F. Campbell, M. Ehlers, J. van Genderen, M. Goodchild, H. Guo, A. Lewis, R. Simpson, A. Skidmore, and P. Woodgate (2012) Digital Earth 2020: towards the vision for the next decade. *International Journal of Digital Earth* 5(1): 4–21. [520]

[3] Ann M. Florini, Sylvie Burns, Yahya A. Dehqanzada, *Secrets For Sale: How Commercial Satellite Imagery Will Change the World,* Carnegie Endowment for International Peace, 2002. http://www.carnegieendowment.org/2000/03/01/secrets-for-sale-how-commercial-satellite-imagery-will-change-world/ipn

[4] See for example: http://www.pecad.fas.usda.gov/pdfs/2009/NGA,%20Chief%20Information%20Officer,%20Jack%20Hild.pdf

[5] Jeff Howe, " The Rise of Crowdsourcing," June 2, 2006. http://www.wired.com/wired/archive/14.06/crowds.html

[6] http://www.b14643.de/Sahara/Kamil_Meteor_Crater/index.htm

[7] http://news.nationalgeographic.com/news/2011/11/111111-sahara-libya-lost-civilization-science-satellites/

[8] http://news.mongabay.com/2011/0622-amazon_tribe_pano_javari.html

[9] http://eijournal.com/2011/satellite-imagery-reveals-predator-prey-behavior-in-coral-reefs

[10] Vipin Gupta, Philip McNab, "Sleuthing form Home," *Bulletin of the Atomic Scientists*, December 1993. http://goo.gl/9wD6E and,

Vipin Gupta, Frank Pabian; Investigating the Allegations of Indian Nuclear Test Preparations in the Rajasthan Desert: A CTB Verification Exercise Using Commercial Satellite Imagery," *Science and Global Security*, Center for Energy and Environmental Studies, Princeton University, New Jersey, Volume 6, No. 2, 1997. http://www.princeton.edu/sgs/publications/sgs/pdf/Vol-6-No-2-Gupta.pdf

The earliest, quite prescient, treatise on the topic, **Commercial Observation Satellite and International Security,** Michael Krepon, Peter D. Zimmerman, Leonard S. Spector, and Mary Umberger, Eds., St. Martin's Press, ISBN 0-312-04035-0, was published in 1990.

[11] See for example: http://ungiwg.ctbto.org/keynotes/satellite-imagery-analysis-international-atomic-energy-agency

[12] See for example: Luke Barrington, "Case Study: First Insight Damascus," *Tomnod* http://tomnod.com/2012/05/05/case-study-first-insight-damascus/

[13] See for example: http://eijournal.com/2011/satellite-imagery-reveals-predator-prey-behavior-in-coral-reefs

[14] See for example: http://www.unitar.org/unosat/

[15] http://www.satsentinel.org/

[16] Nick Hansen, "Rocket science - Iran's rocket programme," *Jane's Intelligence Review*, (September 13, 2012) and "Iranian satellite rocket explodes on launch pad," *Jane's Defense Weekly*, (November 21, 2012) (Subscription required)

[17] CBS/AP, "North Korea vows to restart Yongbyon nuclear complex, capable of making bomb's worth of plutonium per yea,"r http://www.cbsnews.com/8301-202_162-57577407/north-korea-vows-to-restart-yongbyon-nuclear-complex-capable-of-making-bombs-worth-of-plutonium-per-year/ April 2, 2013, 2:43 PM

[18] Jeffrey Lewis, "Long Range Missiles Of Any Kind," *Arms Control Wonk*, 16 March 2012, http://lewis.armscontrolwonk.com/archive/5083/long-range-missiles-of-any-kind

[19] Frank V. Pabian and Siegfried S. Hecker, "Contemplating a third nuclear test in North Korea," *Bulletin of the Atomic Scientists*, 6 August 2012. http://thebulletin.org/web-edition/features/contemplating-third-nuclear-test-north-korea

[20] Niko Milonopoulos, Siegfried S. Hecker, and Robert Carlin, "North Korea from 30,000 feet," *Bulletin of the Atomic Scientists*, 6 January 2012. http://thebulletin.org/web-edition/features/north-korea-30000-feet

[21] Jack Liu, "Update on Preparations for a Possible Third Nuclear Test at Punggye-ri: Is a Detonation Imminent?" *38 North*, 25 January 2013. http://38north.org/2013/01/punggyeri012513/ and "After Kim Jong Un Orders a Nuclear Test: Possible Key Installations and Equipment Identified at North Korea's Punggye-ri Nuclear Test Facility," *38 North*, 24 January 2013. http://38north.org/2013/01/punggyeri012413/

[22] NORSAR, "Nuclear Explosion in North Korea, February 12, 2013: Observations, magnitudes and location estimates," http://www.norsar.no/norsar/about-us/News/NuclearExplosionDPRK12Feb2013