Open Source Analysis in Support of Nonproliferation Monitoring and Verification Activities: *Using the New Media to Derive Unknown New Information*

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Abstract. This paper describes evolving techniques that are synergistically being applied in unique ways to make new information discoveries that might otherwise have likely remained unknown. These techniques leverage multiple freely available open source social media venues, as part of the encompassing "New Media," to derive cueing information for indications of previously unknown and hence undeclared activity. When such cueing relates to physical infrastructure (facilities and equipment), and thus has a strong geo-positional component, it can be followed-up with open source geospatial visualization tools ("geographic browsers" or "virtual globes") and commercial satellite imagery (with its ever improving spatial, spectral, and temporal resolutions) to significantly expand the nuclear nonproliferation knowledge base as will be shown by way of a review of some recent exemplar cases. The methodological application of such techniques can complement other forms of open source data mining for safeguards purposes to improve the likelihood of the remote detection of undeclared nuclear related facilities and/or activities.

1. Introduction: Why we are doing this, and how it can help the IAEA?

The IAEA employs a variety of open source tools and resources as part of its holistic State-level Concept (SLC) approach "*to verify the correctness and completeness of States' declarations so that there is credible assurance of the non-diversion of nuclear material from declared activities and of the absence of undeclared nuclear activities.*" [1] Within the structure of the SLC, the State-level safeguards seek to:

1) Detect undeclared nuclear material and activities in the State as a whole
2) Detect undeclared production or processing of nuclear material in declared facilities and Locations Outside of Facilities (LOF)s
3) Detect diversion of declared nuclear material in declared facilities and LOFs [2]

Open sources can be used to:
• Confirm or deny information/hypotheses; and
• Find new, related, information.[3]

This study illustrates how the repeatable methodology described here, by enlisting the "New Media" (defined as, "*the broadest categorical term to describe all interactive online activities…for information collection, dissemination, and analysis*" [4] [5]) for possible cueing, can provide another open source means to augment the IAEA's other tools and approaches. It can be used to derive new, previously "unknown", information of nuclear nonproliferation monitoring and verification relevance, particularly with regard to the above mentioned State-level safeguards objective #1, "the detection (location and identification) of undeclared nuclear facilities, equipment, material, and activities." Ideally the methodology will also to help eliminate false positives and false negatives (missed real activities).

Moreover, by employing this methodology and not finding any unknowns (null results), while not proving the absence (absence of evidence is not evidence of absence), it might at least help to reduce the level of uncertainty and "*[…] enable the IAEA to draw and maintain a conclusion of the absence of undeclared nuclear material and activities in that State.*" [6]

Open source information (defined here simply as information that is neither classified nor proprietary) is now routinely being used by the IAEA and others to either corroborate what is officially known or to augment (elaborate upon) that which is already known through other information sources. Those other information sources include State declarations, information derived from the IAEA's in field

verification activities, and information obtained from other non-open sources such as from third parties. [7]

This study illustrates how the "New Media" can provide another low-cost, but nonetheless potentially valuable, open source means to derive the requisite outlier clues and cues of "indications of undeclared activity" to potentially lead to the discovery and characterization of "unknowns."

2. Looking for an Unknown: Why this is important for evaluating the presence or absence of undeclared facilities, equipment, materials, and/or activities?

"Open Source" information is just one type of many information sources that constitute the basis for all source information analysis. "*All source information analysis,*" as conducted by the IAEA in the context of Safeguards verification activities, "*is based on the well-defined 'analysis cycle' which begins with tasking, or direction, then continues onto collection, analysis, dissemination and finally feedback to complete the process.*" [8] The key difference in looking for "unknowns" (e.g., undeclared facilities, equipment, materials, or activities of nuclear nonproliferation relevance) is that the ability to clearly task or give direction for an enquiry is generally lacking until first triggered by some kind of anomalous "outlier" cue or tip-off. It is a case of "not knowing what you don't know." As a result, the task of attempting to discover "unknowns" is a formidable one, but one that could be useful to provide additional confidence in the completeness and comprehensiveness of a state evaluation. However, once alerted to any "unknown" of potential safeguards relevance, then the normal analysis cycle can be initiated to support the overall state evaluation (e.g., using commercial satellite imagery to determine the timing and pace of construction or demolition of any pertinent critical infrastructure at either declared or undeclared facilities [9]). Searching for unknowns does not guarantee that anything new will actually be discovered, nor is it meant to replace any of the existing approaches, but the process can be used to at least augment those other approaches in the state evaluation process.

2.1 Evolution of New Media as an Open Source Venue for Dealing with Unknowns

The IAEA has long recognized the value of, and continues to expand its use of, open sources for safeguards applications under the rubric of "other relevant information" to support safeguards implementation at the state level. The IAEA has already enlisted a number of tools and methods to cull diverse and technical open information sources including news media, scientific and technical literature, grey literature, specialist databases, trade data, as well as commercial satellite imagery to potentially obtain indications of undeclared activities for Safeguards monitoring and verification for state evaluations. The IAEA (along with many others) has already published on the applicability of open sources, including *social media*, as both a research tool and information stream. The Nuclear Threat Initiative (NTI) released a report in July 2014, "Redefining Societal Verification" (as part of a larger volume entitled, "Innovating Verification: New Tools and New Actors to Reduce Nuclear Risks"), in which "societal verification" was defined as "*the process by which states or international organizations use information generated by individuals or expert community for arms control or nonproliferation treaty verification.*" [10]

The New Media (of which online "social media" is only a subset) can thus provide a flood of information for what can be, for the most part, largely personal information by the participants that in general can be expected to be of little relevance to Safeguards applications. However, within that huge volume of "chaff" can be at least a few potential grains of unique and valuable information "wheat." One means to more efficiently and effectively glean that larger dataset for safeguards and nuclear nonproliferation relevant applications is through monitoring and engaging online collaborative networks. [11] This form of focused "Crowdsourcing" (soliciting and sharing new information through interested party collaboration networking) can be done through the use of subject themed blogs (e.g., *Armscontrolwonk* [12], *Nukes of Hazard* [13], *American Nuclear Society (ANS) Nuclear Café* [14], and *GEIMINT* [15]) or wikis (*Wikipedia* [16] or *Wikimapia* [17]), either passively as only an observer, or interactively and proactively (e.g., *38 North* [18], *Tomnod challenges* [19]**,** *opennuclearIran* [20], *or* the 1540 implementation monitoring proposal [21]*).* "*OpennuclearIran*" is an anonymous creation

developed from the Ushahidi based platform, freely available on *Crowdmap*. [22] Ushahidi was originally built to crowdsource crisis information (but can also being applied "to monitor elections, curate local resources, or document other activities of interest"). In the case of "*opennuclearIran*", volunteered content is being solicited to "help map, assess, and share information about Iran's nuclear program."

The myriad alternative ways in which social media might be applied to nonproliferation issues, particularly involving social media analytics and big data analytics are beyond the scope of this paper, and others have recently published on some possibilities. [23, 24] Nonetheless, it is worth mentioning that there are a number of websites and virtual globes can aggregate multiple data feeds. *Convoflow* combines network traffic from *Twitter, Youtube, FriendFeed, Meta Café, Blog Catalog, Instagram*, and *Flickr*, and separate the results from each. *Flash Earth* aggregates virtual globe imagery and labelling from multiple sources.

2.2 What do the virtual globes bring to the toolkit?

Virtual globes (e.g., *Google Earth*, Nokia's "*Here*", Microsoft's *Bing Maps, Flash Earth,* Apple's iOS 7 *3D Maps, Skyline Globe, Géoportail*, and *Bhuvan*, etc.) are generally cost-free, but proprietary, venues for visualizing commercial satellite imagery from a 3-D synoptic perspective. And the more that one can draw from cost-free imagery, the more efficiently one can expend financial resources to make supplementary purchases. When thinking of virtual globes, one most often thinks exclusively of *Google Earth*. Of all the virtual globes currently available, *Google Earth* is by far most useful for a variety of reasons, however, one must be fully cognizant that *Google Earth* does not always offer overhead imagery of the requisite resolution, either spatial or temporal, for all areas of the world to adequately conduct the overhead imagery reviews necessary to support all state evaluations. Just as one should not rely exclusively on only one search engine, e.g., *Google*, one should not rely exclusively on only one virtual globe when searching for available online commercial satellite imagery. While *Google Earth* should almost always be viewed as the virtual globe of first resort, multiple virtual globes should always be accessed as part of any comprehensive background review for the best resolutions available. For example, somewhat surprisingly, *Google Earth*'s most recent high resolution imagery of Irbil, Iraq, is nearly a decade old, while those which are available on both "*Flash Earth*" (which includes imagery from both Microsoft's "*Bing Maps*" and "*Yahoo! Maps*") and "*Here*" (formerly *Nokia Maps 3D*) are from 2013 and 2014 respectively. One must also be cognizant of the fact that the satellite imagery available with these virtual globes is constantly being updated, and so what is true today for any given point on earth (e.g., Irbil, Iraq, as accessed for this study on October 15, 2014) may not necessarily be true tomorrow.

3. Exemplar Cases

3.1 Test Positives: Exemplar Verification Exercises Using the New Media

Open source New Media content, together with commercial satellite imagery (and the means to better visualize it in a 3-D geospatial context), has made possible a host of investigations resulting in somewhat surprising geo-spatial 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. [25] Two such examples are provided below. One recent such discovery, involving the work of a small team of subject matter experts and interested academics who were able to combine otherwise disparate pieces of an information puzzle (found exclusively through the use of New Media open sources) into a cohesive and coherent narrative such that they were able to locate, identify, and characterize a potential ballistic missile transport vehicle checkout complex in DPRK. The second example is a case involving the location and identification of potential gas centrifuge manufacturing related facilities in the DPRK. (Although the evidence for each is persuasive, the conclusions cannot yet be proven apart from on-the-ground verification, and hence are not labelled as "True" positives.)

3.1.1 Exemplar: A Potential Ballistic Missile Transporter Checkout Complex in the DPRK

In an interesting case study account, Bryan Lee, Jeffrey Lewis, and Melissa Hanham, describe how they were able to identify and characterize two potential locations for ballistic missile transporter equipment checkout in North Korea by simply engaging the New Media. [11]

On April 15, 2012, the North Koreans paraded what appeared to be six road-mobile intercontinental (KN-08) ballistic missiles. Analysts working at the James Martin Center for Nonproliferation Studies together with collegial *Armscontrolwonk* bloggers in Washington, DC, and Vienna, Austria, were able to follow-up on blog posts by Chinese bloggers concerning what were identified as imported commercial all-terrain vehicles modified to make them suitable as mobile erector launchers for those missiles. [26] Using information published by Joshua Pollock, they were able to view a video from North Korea that depicted ballistic missiles on mobile transporters inside of buildings exhibiting unique elevated roof sections. By closely studying both the parade photos and the frame stills of the buildings from the video, together with dimensioned specifications as found on online brochures for the commercial vehicles, those analysts were able to create digital 3-D models of the transporters, missiles, and the buildings (using freely available modeling software downloaded from the web) to gain a sense of not only what the buildings would look like on the outside, but also the role of the unusual elevated roof sections, and how they would provide the means to operationally check-out the erector portion of a missile transporter while under roof cover. [27] Based on open defector reporting, they were able to locate two buildings on *Google Earth* that met those criteria.

As the analysts reported, all of the information that they used was derived from only open sources as found on the internet, but they were able to successively pick up additional pieces of the puzzle as they continued their investigation. That investigation involved, to one degree or another, all of what the authors defined as the five New Media functional venues: 1) content (e.g., Blogs), 2) social networking (for analysis and translations), 3) data mining (*Google Earth*'s layering), 4) problem solving (determining the search area with cluster of defense sites), and 5) gaming (simulation 3-D modelling). [28]

In those authors' own case study review, they describe the steps necessary for such results and begin with project "Planning." However, project planning was actually a subsequent event, as it was only because of the original unforeseen event (involving the parade display of the purported KN-08 missile and its transporter) that initially triggered a domino effect and initiated the subsequent follow-up project planning.

For the record, at least some, if not all, of the six KN-08s on parade were judged by some observers to be merely mock-ups. [29] Moreover, even the best remote analysis cannot be proven as a true positive without additional source corroboration, ideally with onsite inspection, but such analyses can provide valuable starting points for any subsequent enquiries.

3.1.2 Exemplar: Potential Gas Centrifuge Workshops in the DPRK

In June 2013, R. Scott Kemp, did a guest post on the *Armscontrolwonk* where he noted the identification of a flow-forming machine (suitable for making gas centrifuge rotors) at what was described as the Kanggye General Tractor Plant in a publicly released photo by North Korean media. [30] In September 2013, Jeffrey Lewis, in two additional posts on the *Armscontrolwonk* blog, described some additional investigative work that he had conducted together with Amber Lee on that facility and other reporting of additional computer controlled machine tool workshops in North Korea. [31, 32] They compiled both North Korean media reporting and South Korean media reporting of North Korean defector accounts, as previously culled and shared by researchers on other North Korea focused blogs. They conducted their own research on *Google Earth* to correlate and locate various published ground images. They determined the physical location of a previously unknown potential site for gas centrifuge component manufacturing in the DPRK at the Huichon Ryonha General

Machinery Plant. Based upon a number of interesting observations drawing from the derived information from the New Media, they appear to have made a plausible case.

3.2 False Positives: Mistaken Identities and a Means to Avoid Them

Just as the above cases illustrate some surprising plausible positive results that can arise having significant nonproliferation monitoring and verification consequences, negative results can also arise that can nonetheless prove useful as well. Moreover history has shown that even large facilities can either be overlooked or misidentified. [33, 34] However, before we begin this section which also involves the detection and site characterization by remote means, it is worth taking a moment to reflect on this quote from David B. Sandalow:

> *"Imagery interpretation can take considerable skill and training, and misinterpretation is not difficult. Without strong experience and training, it can be relatively easy to see proof of sinister intent in a benign image, or to miss details that would be conclusive to a knowledgeable photo interpreter. […]This is not just a theoretical problem: in one incident, an image that a magazine claimed was the site of India's 1998 nuclear test turned out to be a livestock pen." [35]*

3.2.1 Exemplar: A suspect gas centrifuge facility in Syria (in actuality a cotton textile plant)

One exemplar case of a false positive involved the identification and characterization of a cotton spinning plant in Hakasa, in northeast Syria, which had originally been alleged to have been under international scrutiny as a possible undeclared gas centrifuge enrichment facility. [36] With a bit of New Media sleuthing, involving a host of New Media sources, including social media photo sharing sites, and volunteered blogger/reader assistance (a German journalist, Paul-Anton Krüger, interviewed the chief engineer who constructed the Syrian cotton spinning plant) and some 3-D modelling by Tamara Patton [37], it was possible to make a compelling dispelling argument. [38] All of the available evidence pointed to the conclusion that the facility, while initially justified as being a focus of additional enquiry, was nothing more than a cotton spinning plant. Moreover, in the event that an IAEA onsite inspection is ever conducted for transparency and verification purposes, such collected background information would prove to be quite useful.

3.2.2 Exemplar: A cylindrical concrete foundation suggestive of a reactor under construction in Iran (in actuality a cylindrical hotel under construction)

As was shown in above case, innocuous facilities have the potential to be mistaken for undeclared facilities of potential interest for treaty monitoring and verification, particularly during early construction phases. One such example can be found where a large, deep and circular excavation had been observable in an area north of, and near, Shiraz. Shiraz is a city in southwest Iran that will be the location of a 10-MWth research reactor, according to declarations Iran has provided to the IAEA. [39] Using *Google Earth* historical archive imagery during the early construction phase of the site in question, the concrete foundation work exhibited some features that were suggestive of what had previously been observed during the early phase of construction of the IR-40 reactor at Arak, Iran. However, various social media user content, involving ground photos and virtual globe labeling, along with associated links to appropriate descriptive construction websites, would have quickly dispelled any nuclear connection. The circular concrete foundation was identifiable as merely that for a 30-story cylindrically shaped hotel (now almost complete, and adjacent to what is now the largest shopping mall in the Middle East). [40] Moreover, the *Google Earth* historical imagery layer also reveals that the site was an amusement park in 2005.

4. Other Factors and Considerations

4.1 Soliciting Active Participation through Crowdsourcing:

With respect to soliciting active outside participation (e.g., crowdsourcing) by interested parties via social media [24], one can envision scenarios whereby an unknown facility might be located and identified through the online posting of reports, line drawings, or ground photographs (along the lines of a the DARPA Challenge "*Red Balloon*" event [41], the US State Department's *Tag Challenge [42]*, *InnoCentive* [43], *Tomnod* [44], the browser-based product "*Dfuze Net"* database [45].There are a number of ways one might solicit nonproliferation assistance from the "crowd" (e.g., as in the case of the *opennuclearIran* website mentioned earlier), but another might be to post on an appropriate blog a simple question similar to "What is this?" or perhaps "Where is this?" A venue could be created that is modelled after the popular *Geoguesser* game in which a ground photograph is posted and participants are challenged to find the location on *Google Earth*. [46] In one exemplar exercise, simply based on the single crowdsourcing cue posted on *Armscontrolwonk*, [47] an alleged strategic rocket forces headquarters of North Korea was successfully located on *Google Earth* using only a ground photograph and general directions provided by North Korean state media. [48]

4.2 Denial and Deception Make Finding "Unknowns" More Difficult

While discovering unknown undeclared facilities, equipment, and material would be sufficient to demonstrate noncompliance with the safeguards regulatory framework, such activities may in actuality be very difficult to find. Some undeclared facilities, such as a "quick and dirty" reprocessing facility, a laser enrichment facility, or a centrifuge plant (especially one built underground), may all have very few outwardly observable signatures, particularly before they become operational. And, as in the case of the suspected North Korean missile mock-ups, it is also possible that "Potemkin village" facilities might be built as "false positive" distractions. With respect to such evasion and countermeasures, a US DOD task force report noted that, *"…ubiquitous information access and widespread observational tools are increasing inherent transparency. At the same time, recognition of such increased transparency by potential or actual proliferants naturally leads to more sophisticated methods of denial and deception.*" [49] One must always be cognizant that, "*The difference between intelligence and scientific research is that intelligence deals with a consciously deceptive adversary*." [50]

Such efforts are not surprising, and they have been extensively employed since the dawn of aerial reconnaissance, although not always successful for various reasons. [51, 52] One example of the potential of camouflage to conceal undeclared nuclear facilities (and to generate "false negatives") can be found in the case of Syria's Dair Alzour (Al Kibar) alleged reactor, which exhibited various forms of signature suppression (e.g., relating to reactor infrastructure, utilities, and physical security); was set in a remote location; incorporated terrain masking; had a "military warehouse" cover story, and was deceptively concealed within an outer façade structure apparently designed and coloured to suggest a Byzantine fortress typical of those in the vicinity along the Euphrates River. [53]

4.3 The Serendipity Factor

One factor that must always be considered, but which cannot necessarily ever be repeatable, is "serendipity" (defined as "an aptitude for making desirable discoveries by accident" [54]). Unknowns might just as well be stumbled upon as found through application of any developing focused search and discovery methodology. However, with each serendipitous discovery, it might be possible to develop a repeatable methodology that improves the likelihood of successfully making future similar discoveries. The same can also be true in looking for indications of undeclared activities. Individuals and collaborative groups, who have developed a capability (through time and experience) to make discoveries using the New Media, might similarly be more likely to make such discoveries in the future (which might otherwise appear to be only serendipity). Other researchers have rightly noted that

"*There is no 'silver bullet' for leveraging social media analytics for treaty verification. It requires the right mix of tools, technologies, and techniques to create and maintain confidence in any verification regime*." [24] We would only add that it also takes the right expert analysts, in the right place (in either close proximity or virtually networked), at the right time, using that "right mix."

Open sources, like any other information sources, can always be subject to error, distortion, and deception, perhaps particularly so when it includes the New Media in all its forms. Finally, open source information is low-cost and therefore is by nature more suspect, however, just because something is cost-free does not necessarily mean that it is valueless.

5. Towards a Successful Methodology: a Step by Step Approach (Repeating the Process as a Basis for Developing a Methodology)

A review of the above cases allows us to discern, distil, and describe the commonalities of the procedures and techniques that led to the successes (and also learn from failures to increase the validity of the learning environment). It is possible to derive an insightful basis upon which to improve the reliability and repeatability of the process. We can see how the New Media has not only become a source of new information, but also as a venue with which to share that new information to place it in the hands of those who can most effectively use it in a nonproliferation context. Each of the cases involved some form of specific cueing, which by itself might not have yielded a discovery. However, when that particular cue was given to a knowledgeable, interested and motivated person, it could become a key to unlock the door of a discovery. It is also clear that the likelihood of discoveries can be increased when there is more than just one such person, but a number of such interested and motivated individuals working collectively as part of a networked collaborative team. The optimum team is one that draws from multi-disciplinary backgrounds, with each team member cognizant of other members' talents and strengths, and where each might most effectively use each type of new information once aware of it. That resulting community has the cumulative years of experience of its members which can also provide the necessary institutional memory to not only recognize what is new or changed, but to also realize the significance of what is new or what has changed. As the old adage goes, "No man is an island," and through the collaborative power of the New Media it is possible to form a connected archipelago of interested parties who can work together, either in small teams in the same office building, or as global dispersed army "crowdsharing" new open-source information that might provide the requisite puzzle pieces that can trigger a nonproliferation monitoring and verification relevant discovery. We can see therefore, that cueing, whether the result of an individual new find or the sharing of a new find with others who might need it as a piece of a larger puzzle, is the very first step in the process of discovering "unknowns."

As the first and most critical step in the methodology, such "cueing" (potentially consisting of only a single report, photograph, map, diagram, etc.) can be obtained from the New Media through the efficient sifting by automated news media monitoring, big data mining (including trade and financial reporting), analytical reports in nonproliferation relevant newsletters, focused blog and wiki posts, emails from colleagues, or any other of the various open-sources found on the Internet (including virtual globes and commercial satellite imagery). That cueing is what is necessary to trigger subsequent action and potentially lead to a significant discovery. Regardless of the source of such tip-offs, once thus obtained, the next steps involve a search for additional information to corroborate or negate the information that formed each cue, and if corroborated to continue the search for additional information to expand the knowledge base and clarify details. The likelihood of success is improved by engaging multiple interested, knowledgeable, and competent individual analysts working together though a collaborative network such that if one person makes a discovery, it can be readily shared among the network. The New Media thus not only is a venue for providing new content of potential interest for deriving indications of undeclared facilities and activity, but also for communicating that content having maximum interest to a targeted ready audience. Figure 1 provides a summary process flow-chart of the various subsequent steps in the derived methodology.

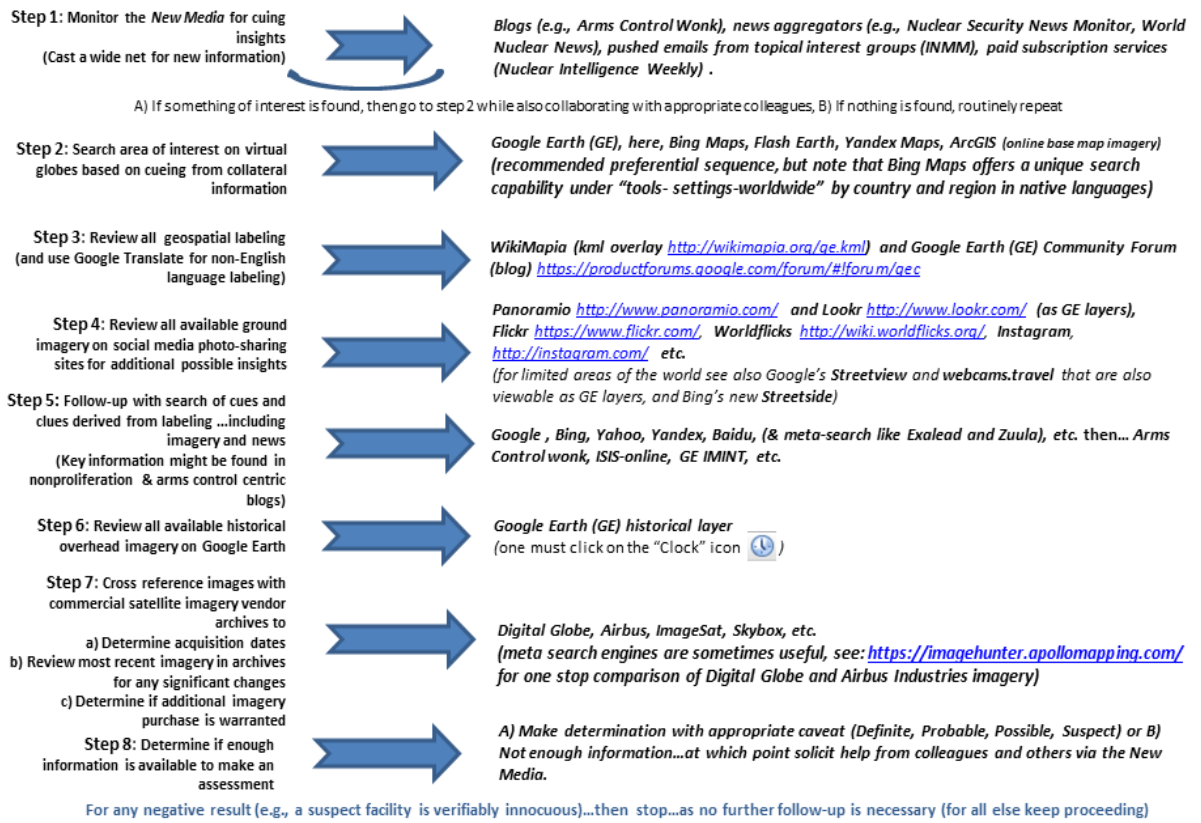

FIG. 1. Methodological Workflow for New Media Crowdsourcing for Nuclear Nonproliferation Relevant Unknowns.

6. Conclusions

In a previous study, the open source geospatial tools were shown to be a "best practices" starting point for further safeguards pertinent investigations regarding undeclared facilities. [55] This study illuminated additional aspects of how those tools can more effectively be used within the broader context of the New Media. It shows through examples how they might be methodically employed to augment other tools and approaches to form part of a focused strategy that also enlists (and potentially even solicits) involvement from social collaborative and interactive networks. The ultimate goal is to initiate a domino effect to progressively acquire additional new pertinent information with each successive step. Moreover, looking for unknowns is like chasing phantoms. One does not know what one does not know. However, the routine implementation of the methodology discussed here might at least improve the likelihood of "serendipity", and thus potentially lead one to find something of nuclear nonproliferation monitoring and verification relevance that was previously "unknown", and even null results contribute to what is known about a State.

In summary, if successfully implemented, the above described New Media-based methodology will be wholly in accordance with the theme of this symposium: "Linking Strategy, Implementation and People." The open source tools and the means with which to use them will continue to be refined with time. It is clear that no single verification approach is enough and the use of these tools and techniques as an independent methodology cannot be expected to serve as a panacea for deriving all previously unknown information for nonproliferation and verification activities. Nonetheless, they can most certainly be relied upon to draw one's analysis closer to the asymptote of full transparency and truth. To quote Jeffrey Lewis, "*We are just starting to scratch the surface of how analysts can use open source information to monitor foreign nuclear programs, particularly integrating modelling tools, satellite images and social media.*" [56]

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