ASSESSING THE POTENTIAL OF SOCIETAL VERIFICATION BY MEANS OF NEW MEDIA

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Introduction

The explosive growth of online social networking sites has been one of the dominant stories of the Internet era. Since their introduction in 1997, social networking sites are now common, with global leader Facebook boasting more than 1 billion users.[1] And the field is not restricted to tech-savvy citizens of the U.S. and Europe. Chinese social media giant Renren reported 178 million total users in its filing for an initial public offering, with 58 million logging on monthly.[2] Russia's Odnoklassniki boasts more than 40 million users, including almost 14% of the population of post-Soviet Kyrgyzstan.[3] And while closed societies such as North Korea block public access to the Internet, social media sites have proven popular enough that the regime hosts several on its internal intranet.[4]

Beyond the size of the social media audience, the technology has generated interest because of its ability to organize large groups of people to solve tasks or provide information. The most prominent examples of this have been in disaster relief operations such as the response to the 2010 Haitian earthquake. In that instance, a global group of volunteers monitored social media such as Facebook or Twitter to plot reports about trapped persons, medical emergencies, and needs for supplies on a common situation map. Response crews were then able to use this real time information to prioritize resources and rescue efforts.[5]

Social media enabled crowds have also proven adept at locating and reporting on less obvious information. A team of MIT students and staff won the Defense Advanced Research Projects Agency (DARPA) "Red Balloon Challenge" in 2009 by finding 10 tethered weather balloons scattered across the United States and reporting the locations back to DARPA in under 9 hours.[6] Not to be outdone, the State Department followed up with the "Tag Challenge" in 2012, which required teams to locate five people in locations on two continents using only a single photograph of the "suspect" as a starting point. The winning team made up of computer scientists from five universities located three of the five suspects in less than 12 hours.[7]

Successes such as these, together with the continuous stream of innovation taking place in the social media arena, have led to calls to apply this technology to the nonproliferation field. Under Secretary of State for Arms Control and International Security Rose Gottemoeller summarized the sentiment in a 2012 speech at the Moscow State Institute of International Relations (MGIMO): "Today, any event, anywhere on the planet, could be broadcast globally in seconds. That means it is harder to hide things. When it is harder to hide things, it is easier to be caught."[8] This has certainly proven to be the case in Syria, where the first evidence of the use of chemical weapons was not delivered via a diplomatic demarche at the UN but through the posting of a victims' video to the video sharing site YouTube.com.[9]

Taken together, examples such as the ones above and others have breathed new life into the concept of societal verification or "inspection by the people." The concept of involving the general public in monitoring and verifying arms control agreements was first proposed in the late 1950s by Seymour Melman[10] and Lewis Bohn[11] as a means of verification of agreements when on-site inspections were not practical. Later thinkers attempted to include a basic form of whistleblowing protection for "citizen

inspectors" in international law,[12] and physicist and peace activist Joseph Rotblat famously proposed to add such protections to every country's domestic law in order to establish societal verification as an integral part of a global treaty to ban nuclear weapons.[13]

While intriguing in theory, societal verification has so far proved unworkable in practice. Not surprisingly, states have been reluctant to grant blanket whistleblowing protection to citizens who may be reporting on issues of state security. Citizens too have proven reluctant to blow the whistle, either out of patriotism and loyalty, or out of fear of reprisal. The obvious question is whether today's new social media technologies can somehow be harnessed to overcome these old obstacles.

At first glance, the challenges seem large. Skeptics are quick to point out another problem with using social media for societal verification: open information can just as easily be used by terrorists and other bad actors as it can by nonproliferation advocates. Indeed, there is some evidence to suggest that disinformation and active attempts to defeat the goals of cooperation are in fact the norm in most online crowdsourcing activities.[14] Beyond subverting an information gathering campaign, what is to stop a terrorist or criminal from using the information provided to target those reported materials?

Even in instances where terrorism is unlikely, skeptics are also right to remind us that unskilled and amateur observers are unlikely to know what to look for or how to accurately report it. This can quickly lead to a situation where responsible agencies or authorities are overloaded with false or misleading information. Moreover, even when the information is correct, observers may not have the technical ability to transmit the data, it may be in a format that is incompatible with existing databases, or it may get lost or garbled in transmission. It seems then that any social media solution risks adding machine reliability to an already problematic situation with eyewitness reliability.[15]

The recent disclosure of large-scale online surveillance by the National Security Agency[16] adds legal uncertainty to the list of technical and behavioral obstacles. While corporations have published elaborate privacy statements that detail their use of user provided information, the legal procedures for governments to access and use these same data are unclear or significantly restricted.[17] Beyond these domestic legal restrictions, it is equally unclear how citizen-derived nonproliferation verification information could be incorporated into existing treaty agreements or compliance mechanisms.

This paper begins with a few definitions that will help to clarify the later discussion on capabilities of these technologies. "Social media," for example is frequently used as a type of shorthand to refer to a broad array of Internet-enabled technologies. Rather than adopt this blanket term, the paper offers a typology of capabilities and attempts to place social media within a broader "new media" context.

Once the definitions and typology have been explored, we provide a summary of some of the research that has been conducted into the field, starting with its basis in social theory and mathematics, and progressing to recent breakthroughs in computer modeling and large scale online experimentation. This section will also highlight some of the empirical evidence documenting the capabilities and limitations of

the technologies as well as provide an overview of concepts such as “crowdsourcing,” “virality,” and “diffusion.”

Following our review of the research literature, we present a comprehensive case study which we believe demonstrates some of the potential of new media technologies to support nonproliferation and arms control goals. Examples are drawn from the fields of commercial satellite imagery analysis, text and data mining of public information, and the gaming and simulation community. With the examples and lessons in hand, we will present a short list of general guidelines for the use of these technologies in a nonproliferation context. Finally, we conclude with some recommendations for policymakers to consider with respect to the use of new media tools.

Literature Review

What is New Media and How Does it Differ from Social Media?

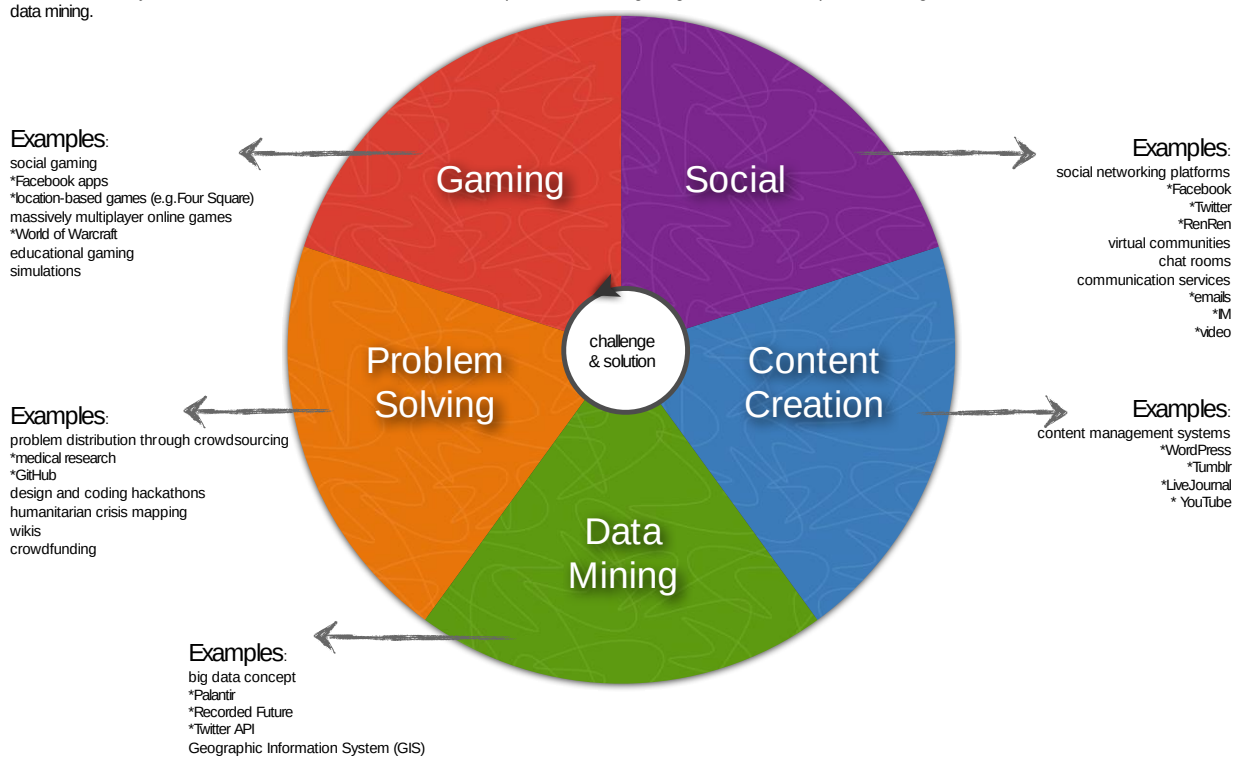
Although network-enabled communication was invented in 1965[18] and the World Wide Web in 1990,[19] both scholars and the general public still disagree on how to name and describe the communication activity that takes place online. Popular contenders have been “Web 2.0” and “the social web,” while communications scholars have tended to prefer the term “new media.” Adding to the confusion is the increasingly common use of the term “social media” to refer to almost any online activity where users can interact with other users. In order to avoid further confusion, this paper will use the term “new media” as the starting point for a functional description of the current online capabilities.

According to the New Media Institute, new media is a “21st Century catchall term used to define all that is related to the Internet and the interplay between technology, images and sound.”[20] Prominent communications scholar Paul Levinson offers a more refined description. For Levinson the broad category of new media shares five essential characteristics: 1) Every Consumer is a Producer; 2) The media are free to the consumer and sometimes to the producer; 3) the media products both compete and act as catalysts for each other; 4) they are more than simply e-mail and online searches; and 5) the underlying software platforms are beyond the control of the individual users.[21] New media can therefore be understood as the top level or broadest categorical term to describe interactive online activities.

In their review of new media capabilities,[22] Lee and Zolotova argue that the typical platform or software-specific approach to describing new media is inadequate. Software platforms often disappear or mimic each other, and it is also common to find platforms that offer multiple capabilities and are difficult to categorize. For this reason, they propose using a functional approach to construct a typology of new media (Figure 1).

Figure 1

***These new media categories represent loosely defined fungible functions that new media can perform. Based on design solutions, resources, and other considerations, any given challenge can be potentially addressed using various combinations of these new media tools. Moreover, many new media platforms/tools can be utilized for more than one of these functions. For instance, Facebook, a social network site mainly used for social interactions, has also served as a platform for social gaming, content creation, problem solving, and data mining.



Typology: Broad New Media Capabilities

*example lists are not all inclusive

It is important to reiterate the point that many common software platforms offer functionality that spans multiple categories. For example, the micro-blogging platform Twitter would seem to fit squarely within the content creation category. Yet the company's own information page says "Twitter is the best way to connect with people, express yourself and discover what's happening," seemingly emphasizing the social aspects of the service.[23] And researchers have weighed in with the claim that Twitter is best understood as a broadcast medium.[24] The implication is any attempt to apply new media technologies must adopt a multifaceted approach and should not be restricted to a single platform or function.

The Science and History of New Media

At its most basic level, new media is a form of communication between people. The underlying structure of this communication began to intrigue researchers in the relatively new field of sociology in the 1920s and 1930s, culminating in Talcott Parson's 1937 landmark *The Structure of Social Action*. Parson's focus on society's institutions led to further research into relations between these institutions, eventually leading back to the interplay between individuals and these institutions. S.F. Nadel's 1957 *Theory of Social Structure* examined how individual roles relate to the surrounding environment, and his descriptions of these interactions strongly influenced the later development of network approach to social theory.

Although "social network analysis" has gained great currency with the rise of social networking sites such as Facebook, John Barnes first used the term in 1954 to describe the interactions among people and groups in a Norwegian fishing village.[25] The utility of the term and his analytical approach was quickly realized, and by the early 1970s, social networks were a popular topic of research in fields as diverse as economics, sociology, political science, and psychology.[26] Oddly enough, the theoretical basis of much of the understanding of 21st century new media traces itself to the research conducted at that time.

Perhaps the most recognizable of this early research was Stanley Milgram's 1967 examination of the "small world problem," named after the phenomenon of two people discovering a mutual and unexpected acquaintance and exclaiming "it's a small world."[27] Milgram was primarily motivated by the question of social distance and was curious about how information could travel between different social groups or classes. Some argued that social groups were essentially closed circles while others felt that some degree of overlap was inevitable. Recent mathematical research had been published that calculated most people had a circle of acquaintances made up of approximately 500 people, and that the odds were therefore better than 50-50 that any two people in that group knew each other. Milgram decided to conduct a live experiment to see if this was true.

He began by asking a simple question: is it possible for a random person in the Midwest to contact a select person in Boston using only his chain of acquaintances? To test the theory, Milgram identified a wheat farmer in Kansas and sent him instructions to transmit a document to a test target—the wife of a Divinity student in Cambridge by selecting one person he knew personally and passing the document along. Astonishingly, the document only passed through two intermediaries and arrived at the target in just four days.[28] Milgram continued the experiment, finally calculating the median number of steps to be five, leading to the famous "six degrees of separation" concept so familiar today.

Later researchers found some methodological problems with Milgram's experiment,[29] but the key findings have held up well. Fundamentally, the experiment demonstrated that it is possible for information to traverse a large network, even if the entire network is not visible from any individual point. Curiously, the experiment also showed that one of his selected targets received more than 50% of his documents from just three people, providing the first empirical evidence of the strong clustering tendency later shown to be a basic feature present in all naturally evolving networks.

While Milgram was interested in the communication between social groups, Everett Rogers was fascinated by how and why companies adopt new technologies. As he studied the problem, he realized one important element was how information moves through a social network. In a departure from most theoretical work, Rogers based his ideas on case studies and empirical evidence drawn from actual experiences in the corporate world. His efforts resulted in a sophisticated model of communication he termed the "Diffusion of Innovations" In 1962.[30] Rogers found four common elements in the spread of new ideas: an *innovation* communicated through distinct *channels* over a period of *time* among members of a *social system*.

Rogers' findings create something of a paradox. The social system for the innovations he was studying was large firms in the 1950s and 1960s. These systems were mostly hierarchical, and therefore relied on group leaders to approve or reject new ideas. These leaders were not acting on their own, however. Rogers found instead that the leader's role was usually as an enforcer of the group norm. The concept of "homophily," the tendency of like-minded people to associate with each other, predicts exactly this type of behavior. The problem is this obviously leads to a situation where group-think must dominate, and information will tend to circulate within the group rather than diffuse through the organization. To account for the fact that information did indeed diffuse through some of these organizations, Rogers concluded some degree of "heterophily" or diversity within the groups must be present.

The most influential attempt to explain this balance mechanism was made by Mark Granovetter in his 1973 paper "The Strength of Weak Ties."[31] In it, Granovetter elaborates on a basic assumption of social interaction called balance theory. Granovetter stumbled across the idea during his PhD research on how job seekers find jobs through their personal networks. When surveyed, most successful job applicants responded that they found their positions through casual acquaintances, and not through the expected close friends or family. Balance theory offered an explanation. Briefly, it says that if Tom is a friend of Dick and a friend of Harry, Dick and Harry are likely to be friends as well. That is because homophily leads to a friend of yours being a friend of mine.

Granovetter's contribution was to apply this logic to the bridge metaphor common to network analysis. He starts by offering a strong form of the balance hypothesis: if Tom is strongly connected to Dick (e.g. close friend) and strongly connected to Harry, Dick and Harry *must* be connected as well. This means it is impossible for there to be only one path between two of the three points. Traditional network analysis says a bridge is the *only* path between two points. If balance theory says that one can never have only one path when strong ties are present, it follows that only weak ties can function as bridges.

Suddenly, the diffusion of information through networks makes sense. It is not the strong ties that are critical for spreading new information, but the much more numerous weak ties. Consider a funny anecdote. If one friend tells another, it will probably circulate among their friendship circle until everyone has heard it, then die as the novelty wears off. If, however, one member of the group passes it on to an acquaintance outside the group, it can spread anew. Weak ties therefore function as bridges and offer access to novel information. Networks composed of multiple weak ties should be excellent at spreading and reacting to new information. And this is the basic principle underlying the "viral" phenomenon so prevalent online today.

Although descriptive theories such as Granovetter's seemed intuitively correct, and offered some empirical evidence to back them up, it was very difficult to model what exactly was going on. The mathematics of graph (network) theory had been laid in the 18th century by Leonhard Euler with his solution of the "Seven bridges of Königsberg" problem which developed the concept of network nodes and links. It was not until 1960, however, that Paul Erdős and his colleague Alfred Rényi were able to build a mathematical model of a random network structure.[32] Armed with this information, the two were also to show how such a network would grow over time.

Remarkably, their model showed that a network would first develop a series of disconnected islands as nodes randomly sent out links to other nodes. This continued for a period of time until a certain threshold of links was established, then the network suddenly underwent a "phase transition." After the transition, a "giant component" emerges and the entire network becomes connected. This was the mathematical proof for the phenomenon Granovetter later observed. Networks are highly efficient transmitters of information, and the larger a network is, the fewer links are required (proportionately) to connect all of the nodes to each other.

As helpful as the Erdős-Rényi model was in proving the efficiency of networks, it still could not explain Milgram's finding that points of an apparently random network somehow seemed to be connected by just a small number of hops. The problem had to wait almost 40 years before computers became advanced enough to model the behavior of real social networks. A major breakthrough occurred in 1998 when Cornell mathematician Steven Strogatz and his graduate student Duncan Watts created a random network model that explained Milgram's "small world" phenomenon as a simple compromise between the basic forces of order and disorder.[33] What their model proved was that most networks, whether "biological, social, or man-made" would exhibit "small world" properties.

The Watts and Strogatz model demonstrated "small world" networks would be everywhere, but it still showed little resemblance to the real world. Most networks, for example, have a marked tendency to develop cliques, or clumps of tightly knit points. Hub behavior is also common, with a single superstar receiving the lion's share of incoming connections. Last, there was no explanation of how networks achieve exponential growth. How is it possible for the World Wide Web to consist of billions of connected pages when each page must be constructed and connected individually?

It was left to the physicist Albert-László Barabási to provide the last piece of the puzzle. By implementing a subtle shift in the rules of network growth, Barabási and his colleague Réka Albert created a model network that closely resembled those in the real world.[34] By assuming that new nodes in a network had a slight preference for connecting to existing nodes, the network would grow rapidly and clusters around the earlier nodes would start to develop. This "rich-get-richer" effect is described mathematically by a power law distribution. In their paper, Barabási and Albert call the networks that exhibit this tendency "scale free," and proved that an extraordinarily complex network like the Internet could arise from very simple starting conditions.

Armed with the basic understanding of networks provided by these theoretical and mathematical models, researchers today have turned their attention to studying online social networks and other new media phenomenon in a quest to better understand the dynamics of these complex systems. Their studies have highlighted a number of capabilities and limitations of these new technologies.

One of the most popular subjects of new media research is the question of privacy and anonymity. Indeed, this is one of the fundamental questions in discussions of the applicability of new media to nonproliferation and arms control issues. Can a citizen in a country such as North Korea or Iran safely communicate a nonproliferation violation without the risk of identification by the regime? Sadly, the

research consensus is this is likely impossible. In fact, networked online systems appear particularly vulnerable to exploitation by determined individuals or states.

Researchers have demonstrated that it is relatively simple to use supposedly anonymous or anonymized information to identify specific individuals. In one case, scientists at MIT and Harvard determined the individual identities of cell phone users simply from the mobility data provided automatically when their phones switched between antennas. Four switches were enough to uniquely identify 95% of the cell phone users in their database.[35]

The ability to identify individuals is even greater when multiple information sources are subjected to machine learning techniques. One study found one third of users who could be verified to have accounts both on Twitter, the well-known microblogging service, and Flickr, a photo-sharing web site could easily be re-identified on the anonymous data stream Twitter provides to advertisers.[36] Stanford graduate students Jonathan Mayer and Patrick Mulcher concluded identifying individuals using basic metadata (e.g. cellular telephone logs containing only origin and destination telephone numbers) was "trivial." They used a combination of computer aided and human searching techniques and publicly available information to uniquely identify 91% of the owners of cellular telephone numbers in under an hour.[37]

Access to new media is an additional concern with respect to its applicability to arms control and nonproliferation. Social media companies routinely grab headlines with announcements of the size of their memberships,[38] but these numbers mask important gaps in participation. Chinese social media giant Sina Weibo, for example, reports more than 400 million active users. Further analysis reveals, however, that the vast majority of these users are middle class and located in China's wealthier coastal regions.[39] Even more telling, the UN's International Telecommunication Union reports only 42% of Chinese use the Internet. The numbers are even lower in countries of proliferation concern such as Iran (26%), Pakistan (10%), and the Democratic People's Republic of Korea (0%).[40] Worse still, these numbers take into account both wired and mobile access, meaning any societal verification effort predicated on a "smart phone" revolution is likely to remain far in the future.

One problem associated with access that is likely to remain unsolved is the issue of bad actors. The paradox of new media is its primary strength—open access— is also a fundamental weakness. Stories of stalking behavior and online bullying are commonplace in today's connected world, as are criminal activities such as identity theft and large scale fraud.[41] This vulnerability is a special concern whenever self-reported information becomes a key factor in decision making. In the 2010 Haitian earthquake relief operation, for example, aid workers delayed operations to some areas based on unsubstantiated reports of violence,[42] and misleading rumors about relief efforts on Twitter led to public relations problems for both UPS and American Airlines.[43]

A more serious issue for societal verification than intentionally false reports is the use of new media for intimidation or retribution. Doctors without Borders reports its relief efforts in Burma have been hampered by online threats and hostility aimed at local workers.[44] Narcotics cartels in Mexico have

conducted a more focused campaign. Rival gangs post YouTube videos with decapitations and other gruesome crimes followed by threats to their enemies.[45] The threats and reprisals are not limited to fellow gang members. One cartel recently posted a video and circulated fliers offering a bounty of 600,000 pesos (approximately $46,000) for the true identity of *Valor por Tamaulipas,* an active Facebook and Twitter user who posts information related to drug crimes and corruption in the Mexican state of Tamaulipas.[46]

Information Diffusion, Crowdsourcing, and Data Mining

Moving away from common limitations, new media also offers important new capabilities for nonproliferation efforts. Rapid information diffusion is perhaps the most familiar example. The December 2013 theft of a Cobalt-60 source in Mexico was publicized on social media and authorities detailed the theft and shared important safety information about radioactive contamination. Later, when six men reported to a hospital for treatment for radiation exposure, word of their admission was first announced on Twitter.[47] In less than five days, authorities had announced the theft, recovered the materials, and arrested the leading suspects.

Academics have focused on the use of Twitter in information diffusion because of the ease of access to its information. The research results provide good evidence to back up results like those seen in Mexico. In one experiment, a sample of 106 million tweets was used to demonstrate that any information "re-tweeted" or shared by one user with another will reach a minimum of 1000 additional users. Moreover, this information is shared almost instantly, with one-half being shared within an hour and 75% within one day.[48]

Despite many descriptive studies of information flow across social media networks, how it happens remains poorly understood. Most people today are familiar with the concept of "virality," where a particular news story or, more commonly, video clip is shared with millions of people. Yet, attempts to induce this viral effect have been uniformly unsuccessful. The reason is the inherent randomness of complex systems. Duncan Watts likens virality to a forest fire. Millions of lightning strikes hit forests every year, but only a tiny fraction become forest fires. To do so, there must be some ideal combination of tinder, dryness, proximity of other trees, wind conditions, and so on.[49]

Researchers have been more successful understanding how individuals influence each other online. Returning to the world of Twitter, studies have shown that influential users usually gain their influence over a period of time and through a concerted effort, often by focusing on a limited number of topics.[50] And while most studies measure influence through online metrics such as "re-tweets" on Twitter or "Likes" on Facebook, there is some evidence that online influence can be translated into real-world action. In one of the most well-known studies, UC San Diego researchers teamed with Facebook data scientists to examine voting patterns.[51] What they found was a tiny but significant influence effect among connected people on Facebook. Although the effect was very small, when it was multiplied across the 61 million people in the study they estimate Facebook sharing was responsible for bringing an additional 340,000 people to the polls in the 2010 U.S. Congressional elections.

After information diffusion, crowdsourcing is probably the most well-known new media capability applicable to nonproliferation concerns. The term was popularized by *Wired* magazine editor Jeff Howe in 2006,[52] and today scholars generally accept the term to mean "online, distributed problem solving."[53]

The problem-solving aspect generally divides into two parts. On the one hand, crowds are very good at solving discrete problems such as estimating the location of lost hikers[54] or the number of beans in a jar.[55] In fact, once a crowd approaches 1000 people, it will likely outperform an expert assessment 90% of the time.[56] More common, however, is the use of crowds in goal-seeking processes. Wikipedia is one example of this type of crowdsourcing, as is the Linux open-source computer operating system, and the T-shirt design firm Threadless.

The goal-seeking aspect of crowdsourcing is well-suited for complex problem solving, and the 2009 Defense Advanced Research Projects Agency's (DARPA) "Red Balloon Challenge" has already demonstrated the applicability to nonproliferation and terrorism concerns.[57] In that contest, an team led by students and researchers at the Massachusetts Institute of Technology (MIT) managed to locate 10 weather balloons tethered at undisclosed locations across the continental United States in less than nine hours. The State Department conducted a similar experiment called the "Tag Challenge" in 2012, but this time the task required locating and photographing five "thieves" located in five different cities in the U.S. and Europe. MIT again had the winning team, identifying three of the five individuals within 17 hours.[58]

As the MIT examples suggest, for goal-seeking and complex problem solving, expert crowds are the most successful.[59] A study of the performance of groups of scientists who teamed to address the most difficult technical problems posted by crowd-based research firm InnoCentive showed that one-third were solved. This is in comparison to the 0% success rate achieved through traditional research and development channels.[60]

Incentives, process, and structure all play important roles in successful crowdsourcing. Surprisingly, monetary incentives are only one factor that encourages participation.[61] Reputation and "bragging rights" also seem to be important, and the introduction of a simple reward system like a "most popular" or "top 10" list can also influence participation and successful outcomes.[62] With respect to process, four elements are common to successful crowdsourcing efforts: pre-selection of the crowd; visibility and accessibility of peer contributions; aggregation of the efforts; and some form of remuneration.[63] Additional studies show active management of the effort is an important factor, and outcomes can be enhanced by thinking through the basic questions of what the specific goal is, who will conduct the task, how it will be structured, and why people would want to participate.[64]

Data mining, or more formally, Knowledge Discovery in Databases (KDD),[65] is the final new media capability that will be highlighted. There have been numerous attempts to estimate how much information is openly available on the World Wide Web, but a recent and ultra-conservative estimate is 1.6 billion unique web pages.[66] Additionally, a 2001 estimate found at least 400-550 times that amount of information hidden in the "deep web," in places such as password protected databases or

subscription-access publications.[67] Data mining is a set of computer assisted tools and techniques that can help to discover useful information buried within this mass of data.

Many of the most successful application of data mining techniques rely on so-called "supervised learning" methods, where the results obtained by a computer algorithm are revised and refined by a human domain expert.[68] In general, data mining relies on statistical tools to either find similarities in data or predict outcomes or variables from data. It has been used successfully in numerous fields ranging from insurance fraud detection[69] to aviation safety analysis[70] to prediction of novel biological warfare agents.[71]

Much of the work in data mining has been with structured data, such as individual fields in a database or spreadsheet. Deriving useful information from unstructured data such as text is an active field of research which has received increasing attention in the wake of social media's publicized role in the Arab Spring.[72] Research has focused on content analysis and topic identification,[73] information extraction,[74] and sentiment analysis.[75] Combining various approaches, scholars have claimed some success in identifying and predicting future events, including stock market returns,[76] movie box office revenues,[77] and political protests in Latin America.[78]

In addition to textual data, multimedia information retrieval and analytics[79] is also an active field of data mining research. Since much of the content online consists of images, video, and audio files, a variety of machine-assisted techniques have been developed to aid in information discovery. However, despite some advances in the field of facial recognition,[80] the field remains very much in its infancy.[81]

Acknowledging the full span of new media capabilities and limitations, the following case study attempts to demonstrate the current state of possibilities with respect to nonproliferation problems.

Case Study: Applying New Media Tools

On April 15, 2012, North Korea paraded what appeared to be six road-mobile intercontinental ballistic missiles, quickly identified in the media as KN-08 ICBMs, through Kim Il Sung Square in Pyongyang.[82] Attention immediately focused on these unusual vehicles, after Chinese bloggers identified them as Chinese-manufactured transporter-erector-launchers used by China's strategic missile forces.[83]

Chinese officials would later state that the Chinese firm in question had only exported the vehicles' chassis, which can be used for a variety of civil purposes, including logging and construction. Although even the chassis export appeared to violate sanctions on North Korea, the Chinese showed evidence that the North Koreans had provided a false end-user for the vehicles and claimed they had added the erectors and other specialized equipment to the chassis themselves.[84]

Using the full array of new media approaches described in this report, it is possible to make some preliminary judgments about China's claim, as well as North Korea's infrastructure for producing transporter-erector-launchers. Although it is hard to believe that the Chinese were not aware that North Korea would use the vehicle chassis for its illicit missile program, the available evidence does suggest

that North Korea added the erectors itself at existing facilities known to assemble North Korean transporter-erector launchers. What follows is an integrated case study on using new media to resolve a difficult question in the field of arms control, disarmament and nonproliferation.

The WSV Sale

Following the April 2012 parade, Chinese officials told the United Nations Panel of Experts that a Chinese firm, the Wanshan Special Vehicle Company (WSV), had exported six heavy-duty vehicle chassis to North Korea in 2011.[85] The delivery appears to have been made in two shipments: two chassis in May 2011, followed by another four chassis in October 2011.[86]

In retrospect, information concerning the shipments was available in the public domain. The State-owned Assets Supervision and Administration Commission of the State Council (SASAC or 国资委) announced the export of heavy-duty vehicle chassis to an unnamed foreign customer, as did WSV.[87]

The two statements mentioned neither the number of chassis nor the identity of the customer, but did indicate that the customer – China's first foreign customer for such vehicles – paid 12 million RMB in advance on a 30 million RMB order.[88]

Chinese officials subsequently claimed that the North Koreans had claimed the vehicles were to be used in logging by North Korea's Ministry of Forestry. Although the story is difficult to believe, logging and construction are plausible civil uses for the otherwise highly specialized vehicles.

Figure 2 April 15, 2012 Parade Image and Marketing Photo of the Chinese WS51200

A marketing photograph online depicted a chassis of this type with only a cab attached. One previously unresolved question is whether the Chinese exported fully assembled launchers, or just the chassis-and-cab assembly, leaving North Korea to mount the launcher and other specialized equipment.

Kim Jong Il's Efforts to Defend the Country

In 2013, North Korea released a commemorative video entitled *Kim Jong Il's Efforts to Defend the Country.* This video is available on YouTube, where pro-North Korean groups post the country's propaganda. Although it is strange to think of North Korea using social media extensively, the country's state-run propaganda apparatus and affiliated groups in foreign countries make extensive use of social media platforms to share and distribute the regime's propaganda to a wider audience. This propaganda

serves an important function in a highly ideological system such as North Korea. It also provides outside analysts information about an otherwise closed country. Factories closed to foreigners are routinely exposed in footage of North Korean leaders conducting inspections.

Kim Jong Il's Efforts to Defend the Country contains the only footage of the inside of North Korea's facility for completing assembly of transporter-erector-launchers for ballistic missiles. The footage includes a few seconds of footage showing three clips of Nodong transporter-erector-launchers inside a spacious, rectangular, high-bay building, as well as a few more seconds of footage of a very similar building containing KN-08 transporter-erector-launchers. Kim Jong Il is shown in some frames, looking at one of the Nodong transporter-erector-launchers. The first public description of the film, along with still images, appeared on the website, *North Korea Leadership Watch*, which regularly analyzes North Korean propaganda.[89]

Figure 3 Stills from *Kim Jong Il's Efforts to Defend the Country*

Modeling the Building from the Inside Out

The internal images show a building that is quite distinct. It is, in fact, possible to model the outside of the building based on its unusual pattern of windows as well as the cupola-like structure near the center

of the building. The windows run along only one of the long sides of the building, suggesting it is either partially buried or has an adjoining structure on the opposite side. The windows along the long side and at the ends of the building are also spaced in an irregular manner, making an identifiable pattern.

Modeling software is not new, but it is for the first time widely available, free, and easy to use. One of the most popular is Trimble SketchUp (previously of Google), which allows a user to create a three-dimensional digital model of a location, and geo-locate it in Google Earth. When Google sold the software to Trimble, its marketers primarily focused on the architects. Fans, however, continue to model the world's most famous structures, and Google still shares them on Google Earth.

Using SketchUp, we created a model of the inside of the building based on the video footage. Modeling the building reveals a number of interesting details, including its approximate dimensions – as well as the fact that the two clips seem to be in *different* buildings, based on the windows and the roof.

Figure 4 Comparison of Stills with the Virtual Model

Using this process, we created external models of the two buildings – one with a square cupola, and another with a larger cupola that spans the length of the roof.

Figure 5 Artist Sketches of Nodong Building and KN-08 Building

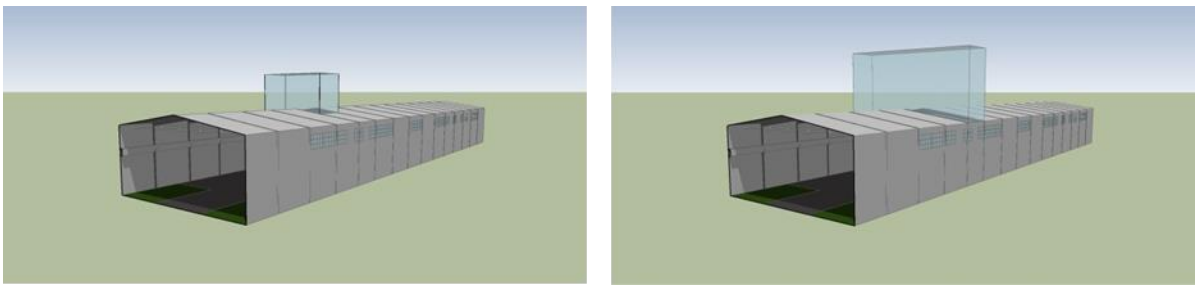


Figure 6 Square Indicates the Initial Search Area

Defining the Search Area

Where might such unusual buildings be located? Google Earth houses an enormous repository of sub-meter resolution satellite and aerial images, including fairly comprehensive coverage of built-up areas of North Korea.[90] Additional images can be purchased from other providers, such as Astrium.[91] The only problem is where to start looking.

A number of defector accounts describe the location of various North Korean defense industries, including locations linked to the production of vehicle chassis and the final assembly of transporter-erector-launchers. A Korean-speaking student, Amber Lee, mined social media sites and other electronic resources containing defector accounts to create a search area. Although the accounts differ from one another, many descriptions of North Korea's facilities to assemble missile launchers converge on an area in Chagang (Jaggang) Province that is well known as the heart of North Korea's defense industries. (Chagang is also a center of forestry, an amusing coincidence given the stated end-use for the Chinese vehicles.)

For example, a North Korean defector, Ko Chong Song, published a book in Japan describing the locations of North Korean defense enterprises, stating that North Korea produces "missile launchers" at the No. 81 Factory located in the "Chungsonggan workers' district, Songgan County, Chagang Province, about 2.5 to 3 kilometers from Songgan-up."[92] Ko offers a caution, however, stating that it is possible the No. 81 Factory only produces some component for launchers, with final assembly done elsewhere.

Another account, posted online by an anti-DPRK dissident group, describes a gruesome incident at the "No.11 munitions factory (Hakmu worker's district six kilometers northwest of Jonchon, Jagang) where missile launchers are manufactured…" Jonchon and Songgan are close to one another, lying about 10 kilometers apart along a river valley.

Songgan, Chunsonggan and Jonchon (Chonchon) all appear in the Gazetteer maintained by the National Geospatial-Intelligence Agency.[93] Hakmu is not – although the description of the place being about 6 km NW of Jonchon is consistent with a mention of the same place in a survey conducted by UNICEF and the World Health Organization.[94] Ko, too, mentions Factory 11 – although he claims it is near Songgan.

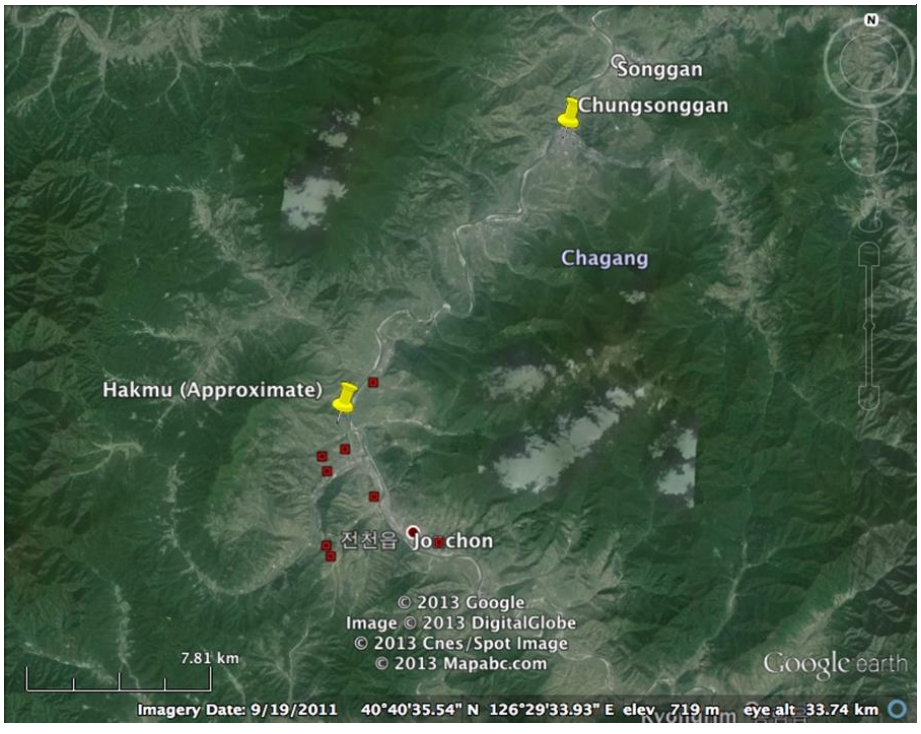
These areas are within a few kilometers of each other, creating a manageable search area centered on the river valley between Songgan and Jonchon, particularly the Chungsonggan and Hakmu Worker's Districts, which lie between the two locations.

There are other locations of possible interest mentioned in these and other defector accounts, but mapping the defector accounts reveals that what appear to be two different locations -- Chungsonggan and Hakmu Worker's Districts -- are close enough to be related. This is became our initial search area.

The ten kilometers along the river valley between Jonchon and Songgan represent a manageable search area, but the problem can further simplified through crowdsourcing. The social media site Wikimapia and the North Korea Uncovered KMZ file offered by the blog North Korean Economy Watch provide locations of many of North Korea's known defense sites, including surface-to-air missile sites, underground facilities, and other locations. Although the No. 81 and No. 11 Factories are not included, clusters of surface-to-air missiles sites often help identify locations that the North Koreans regard as important installations.[95]

The area six kilometers to the northwest of Jonchon – consistent with the location of the Hakmu Worker's District – appears to be well-defended. We started there.

Figure 7 Search Area Showing Surface-to-Air Missile Sites



North Korea's Final Assembly Facility for Transporter-erector-launchers

Less than one kilometer from a surface-to-air missile site, and 4.6 kilometers northwest of the Jonchon train station (a proxy for central Jonchon), lies a building that matches one of our models. The building is located at 40°38'44"N, 126°25'58"E. We will call this Site A.

Figure 8 Site A

Immediately, several interesting details emerge.

The building at Site A is a close match based on the modeled dimensions and the windows. The single row of high, clerestory windows on the south side of the building results from the presence of a lower part of the structure adjoining the hall. The completely windowless opposite side appears to be flush with a shed-like structure. The windows at the eastern short end match very closely. The large cupola is revealed to be a curved, fan-like structure.

Historical satellite images suggest that the two roofs are, surprisingly, from the same building. North Korea remodeled it between 2004 and 2011 – probably shortly after negotiating for the export of the KN-08 chassis.

Figure 9 Historical Comparison of Site A in 2004 and 2011

Our modeling, based on the length of the shadows in each image, shows that the North Koreans probably added the roof structure to accommodate an erected KN-08 launcher.[96] This detail provides additional confirmation of the site's purpose, as well as indicating that China probably only exported the bare chassis. The launcher was added here, near Jonchon.

Figure 10 Model of North Korea's Facility to Assemble Transporter-Erector-Launchers

Figure 11 Model Depiction of Erected KN-08

Along with the US-Korea Institute of Johns Hopkins University, which maintains the blog 38North, we purchased new satellite images of the site from Astrium, including a low-angle satellite view that shows the windows running alongside the south of the building. They are not evenly spaced, presenting the opportunity to match the inside of the building with the outside. The matching window pattern would seem to suggest that, at a minimum, the KN-08 launchers were located in the building at Site A.

Figure 12 Window Pattern Visible Along South Side of Building[97]

The windows in one video clip of the Nodong launcher, however, do not seem to match. In particular, one image shows a Nodong with a row of continuous windows behind it. It is possible that the windows

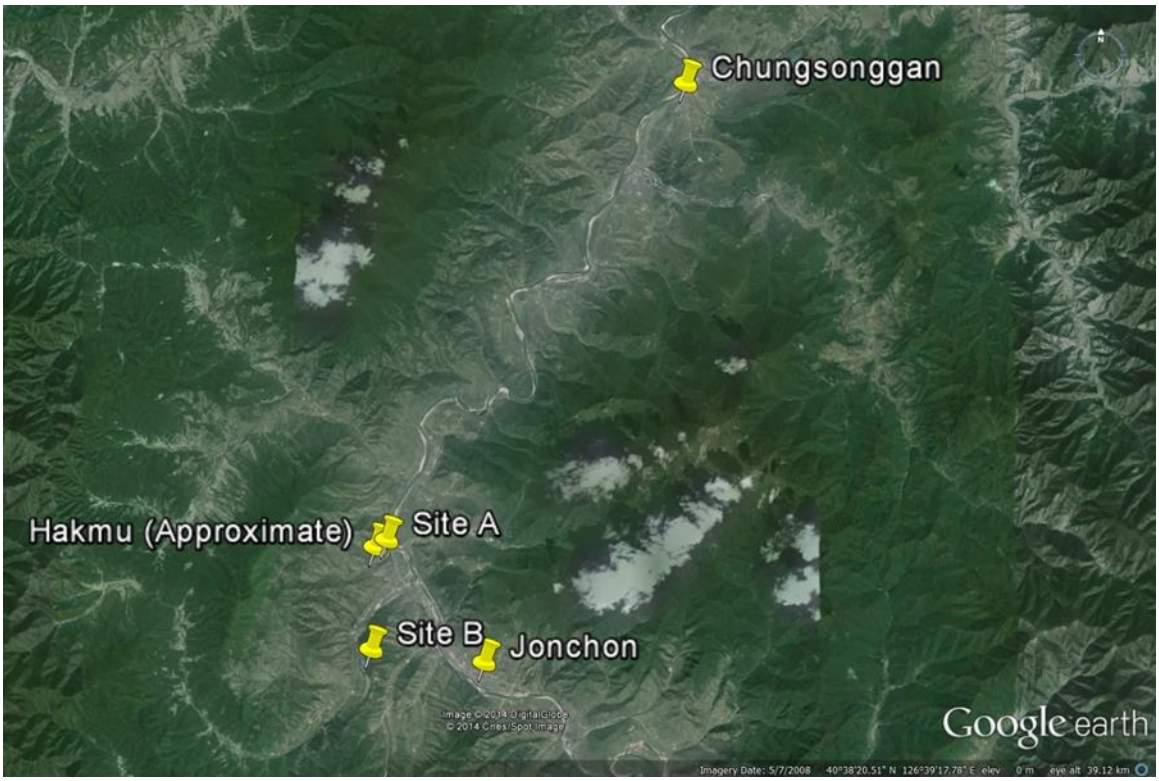
were altered when the roof was remodeled.

There is another possibility. In addition to the building at Site A, a second, nearly identical building, exists a few kilometers away at what we call Site B: 40°36'43"N, 126°25'34"E. This building, too, received a new cupola sometime before 2011.

Figure 13 Historical Comparison of Site B in 2004 and 2011

Based on the defectors' accounts, it appears that these are North Korea's most important facilities for the final assembly of transporter-erector-launchers.

Figure 14 Locations of Site A and Site B in the Search Area



Implications

As it turns out, a persistent analyst can identify North Korea's primary facilities for the assembly of ballistic missiles transporter-erector-launchers by combing footage posted to YouTube, SketchUp simulations of the building, published defector accounts, mapping projects like North Korea Uncovered, and commercial satellite images. In isolation, none of these tools would offer much insight into North Korea's illicit nuclear and missile programs. Together, however, it is possible to establish with some confidence when and where North Korea fixed the erectors and launchers to imported Chinese heavy-duty vehicle chassis.

In a limited sense, many of these steps were possible thirty years ago -- for example, one might have been able to procure a North Korean propaganda film, perhaps learning about it at conference (an analogue of crowdsourcing). One might have been able to draw the building, hoping it would show up in another film. One might also have been able to interview defectors, or even have a colleague mail transcripts of an interview. If one were lucky enough to work in the intelligence community, an overhead image might be available. Each step, however, would have been labor-intensive – perhaps prohibitively so.

Today, nearly all of this information is available working from one's office or a coffee shop with decent Internet connection – films on YouTube, software to model buildings, and Internet websites of defector accounts. Questions can be asked, and answered, by email or social media. Images and models can be shared online. Our own team operated virtually, using email and DropBox to connect participants from offices in Monterey, California; Washington, DC; and Vienna, Austria. When we purchased satellite images, we simply downloaded them. Each of these new media tools exists because of the dramatic decline in the cost of sharing information, in both resources and time. Those declining costs open up new vistas for research in the field of arms control, nonproliferation, and disarmament.

Some Considerations for New Media in Nonproliferation

The case study has demonstrated the capability of any researcher to use new media technologies to discover new information related to nonproliferation and arms control. Aside from the task-specific lessons learned, there are a number of general considerations regarding new media that policy makers should keep in mind as they prepare to take advantage of the opportunities provided by these technologies. These guidelines provide a broad outline of tasks and considerations that will facilitate the integration of new media tools and techniques into existing nonproliferation and arms control efforts.

Planning

Planning is the beginning of all successful new media efforts. Before the effort begins, some person or group must assume the role of manager and decide the intent of the project and share that intent with the members of the project team. The project intent should explicitly state the goal or outcome it hopes to achieve and also the intended audience (in an outreach effort) or customer (for information gathering or analysis). Once these have been defined, the manager will have taken the first step towards

determining what resources need to be applied to the project as well as what success metrics to apply and any feedback mechanisms that should be incorporated.

A new media project plan allows analysts to work more efficiently by limiting the search and processing efforts to a defined set of sources and platforms. Although this sounds risky, as some information will be missed or left out, the information and analysis that is obtained will be more likely to meet the stated project goal. Human subject matter expertise is always required to refine and interpret results, but the effort taken up front to steer the research effort is often the chief discriminator between successful and unsuccessful projects.[98] An early determination of the sources and software tools or platforms required will also help to decide on what resources will need to be devoted to the project.

A final planning factor that is of special consideration for government users of new media is administrative and legal issues. There is still much debate over the Constitutionality of using online information for analysis,[99] and even in cases where Constitutionality is no concern, statutory issues such as copyright, privacy act information, or Health Insurance Portability and Accountability Act (HIPAA) privacy restrictions may still apply.

Use all Functions of New Media

As shown in the typology (figure 1), new media functions are not exclusive. Often, as demonstrated in the case study, the optimal solution to a nonproliferation challenge will be found by combining different elements from the various functions. For example, in order to identify the suspected TEL assembly sites, the team used information provided by various blog entries. Blogs fall under the Content Creation function, but the Social function was used to help analyze blog content and translate some of the Chinese and Korean language entries. Simultaneously, the Problem Solving function was used to identify suspected sites based on surface to air missile clusters. In the end, some element of all five functions was required to find the solution to the location of the assembly site.

Know the Capabilities and Limitations

Users and managers must understand the capabilities and limitations of new media. These may be technical, such as the available resolution of commercial satellite imagery, or conceptual, such as the importance of “weak ties” for information sharing in networks. Regardless, everyone involved in applying new media should have a basic understanding of what it can and cannot do and why. Such an understanding not only speeds up planning and decision making, but allows ensures human judgment remains at the center of the process.

Management is Still Required

Successful new media initiatives require a substantial management effort. The distributed nature of much of the technology often means traditional management structures cannot coordinate actions or make decisions in time to respond to changing information. On top of this, some of the outputs from new media require refinement and interpretation before they are usable. Finally, the work may require allocating scarce manpower or computer resources, or the development of an appropriate incentive scheme to encourage outside users to participate.

All of this is to say that the management requirements of a new media effort are likely to be equal to or greater than those using more traditional methods. Managers should plan accordingly.

Conclusion and Next Steps

When Seymour Melman and Lewis Bohn first proposed "inspection by the people" in the mid-20th century, the idea of an unsupervised electronic network providing instant communication between any two people on the planet would have sounded like fantasy. Today, despite the existence of just such a network, societal verification in the sense of whistleblowing still faces many of the same obstacles it faced in Melman and Bohn's time. Citizens are reluctant to report violations related to security issues, either out of support for their state or fear of the repercussions. Even when someone does want to report, the average person does not have the expertise required to document or properly verify a violation. And, if a report were received, there is no mechanism to incorporate this type of notification into existing treaty procedures.

The strength of a new media approach to nonproliferation is it does not rely on a whistleblowing model. Instead, new media presents an opportunity for subject matter experts and interested amateurs to harness existing information and quickly and efficiently pool resources for interpretation and analysis. The case study presented here offers a glimpse of the scope of information that a coordinated new media effort can produce in a very short time and with limited resources. Starting from a video shared over social media, the research team was not only able to identify previously undisclosed missile facilities, but offer a compelling hypothesis for the types of activities undertaken there. Furthermore, the team was able to provide evidence confirming the Chinese story that the truck chassis in question were most likely modified after they had been shipped to North Korea.

The capabilities of new media demonstrated here are focused on a typical information discovery problem and are only a small sample of possibilities. This paper sampled a considerable body of theoretical and empirical research to show that information travels rapidly across a network, individual nodes (information sources) in any network can be discovered by any other member of the network, and properties such as "virality" and "influence," while not fully understood, are increasingly able to be measured and described. Moreover, scientists and industry have greatly refined the art of crowdsourced collaboration, and learned how to apply those techniques towards solving some of the most world's most difficult problems.[100] Large scale nonproliferation information campaigns, virtual site inspections for training or testing inspection protocols,[101] and expert "swarming" for problem solving are some ideas that could be easily developed further based on the principles discussed in this paper.

Business, academia, and society at large have all witnessed enormous changes brought on by new media technologies. We believe there is clear opportunity for these technologies to benefit the arms control and nonproliferation communities as well. As is clear from the case study, the technical barriers to entry are low and the information payoff can be very high. Understanding the technology is only part of the challenge, however. To realize its full potential, decision makers must also be willing to devote the necessary resources—people, time, and equipment. When both aspects are combined, new media technologies and methods offer an efficient, effective, and low cost means of addressing

nonproliferation information discovery challenges. We hope the success shown here points the way towards further exploration of the five new media functions to address other nonproliferation challenges.

Notes:

[1] Zack Whittaker, "Facebook hits 1 billion active user milestone," CNET, http://news.cnet.com/8301-1023_3-57525797-93/facebook-hits-1-billion-active-user-milestone/.
[2] Renren Inc., "Form 20-F," (April 23, 2013).
[3] Ilya Lukash, "Odnoklassniki localized into Kyrgyz," in *Net Prophet* (Transitions Online, 2012).
[4] Ashley Moreno, "Social Media in North Korea," *Austin Chronicle* 2013.
[5] J. Heinzelman and C. Waters, "Crowdsourcing crisis information in disaster-affected Haiti," (United States Institute of Peace, 2010).
[6] DARPA, "MIT Red Balloon Team Wins DARPA Network Challenge," (2009).
[7] Alex Rutherford et al., "Targeted Social Mobilisation in a Global Manhunt," *arXiv preprint arXiv:1304.5097* (2013).
[8] Rose Gottemoeller, "Arms Control in the Information Age," (2012).
[9] Rob Williams, "Cameron cites 'growing evidence' of Syria chemical weapons use as video emerges," *The Independent*, 4/26/2013 2013.
[10] Seymour Melman, "How Can Inspection Be Made To Work," *Bulletin of the Atomic Scientists* XIV, no. 7 (1958).
[11] Lewis Bohn, "Non-Physical Inspection Techniques," *Arms Control, Disarmament, and National Security, Braziller, New York* (1961).
[12] Dieter Deiseroth, "Societal Verification: Wave of the Future?," in *Verification Yearbook 2000* (London: Verification Research, Training and Information Centre (VERTIC), 2000).
[13] Joseph Rotblat, Jack Steinberger, and Bhalchandra Udkaongar, *A Nuclear-weapon-free World: Desirable? Feasible? ,* Pugwash Monograph (Westview Press, 1995).
[14] Victor Naroditskiy et al., "Crowdsourcing Dilemma," (arXiv:1304.3548, 2013).
[15] Gary L Wells, "What do we know about eyewitness identification?," *American Psychologist* 48, no. 5 (1993).
[16] Glenn Greenwald, "Edward Snowden: the whistleblower behind the NSA surveillance revelations | World news | The Guardian," *The Guardian*, 2013-06-09 2013.
[17] For a list of international privacy directives see http://www.informationshield.com/intprivacylaws.html
[18] Barry M Leiner et al., "A brief history of the Internet," *ACM SIGCOMM Computer Communication Review* 39, no. 5 (2009).
[19] Tim Berners-Lee, Mark Fischetti, and Michael L Foreword By-Dertouzos, *Weaving the Web: The original design and ultimate destiny of the World Wide Web by its inventor* (HarperInformation, 2000).
[20] http://www.newmedia.org/what-is-new-media.html, accessed 12 December 2013.
[21] Paul Levinson, *New New Media*, 2nd ed., Penguin Academics (Upper Saddle River: Pearson, 2013).
[22] Bryan Lee and Margarita Zolotova, "New Media Solutions in Nonproliferation and Arms Control: Opportunities and Challenges," (Monterey, CA: Center for Nonproliferation Studies, 2013).
[23] https://about.twitter.com/, accessed 12 December 2013.
[24] H. Kwak et al., "What is Twitter, a social network or a news media?" (paper presented at the Proceedings of the 19th international conference on the World Wide Web, 2010).
[25] JA Barnes, "Class and Committees in a Norwegian Island Parish," *Human Relations* 7(1954).
[26] J Clyde Mitchell, "Social networks," *Annual Review of Anthropology* 3(1974).
[27] S. Milgram, "The small world problem," *Psychology today* 2, no. 1 (1967).
[28] Ibid.
[29] J.S. Kleinfeld, "The small world problem," *Society* 39, no. 2 (2002).
[30] Everett M. Rogers, *Diffusion of Innovations, Fourth Edition*, 4th ed. (Free Press, 1995).
[31] M. S. Granovetter, "The strength of weak ties," *American journal of sociology* (1973).
[32] P. Erdős and A. Rényi, "On the evolution of random graphs," *Magyar Tud. Akad. Mat. Kutató Int. Közl* 5(1960).
[33] DJ Watts and SH Strogatz, "Collective dynamics of'small-world'networks," *Nature* 393, no. 6684 (1998).
[34] A.L. Barabási and R. Albert, "Emergence of scaling in random networks," *Science* 286, no. 5439 (1999).
[35] Yves-Alexandre de Montjoye et al., "Unique in the Crowd: The privacy bounds of human mobility," *Scientific reports* 3(2013).

[36] A. Narayanan and V. Shmatikov, "De-anonymizing social networks" (paper presented at the Security and Privacy, 2009 30th IEEE Symposium on, 2009).
[37] Mayer NSA Jonathan Mayer and Patrick Mutchler, "MetaPhone: The NSA's Got Your Number « Web Policy," in *Web Policy* (2013).
[38] Whittaker, "Facebook hits 1 billion active user milestone."
[39] Steven Millward, "8 Facts About Sina Weibo Users That All Marketers Should Know," TechinAsia, http://www.techinasia.com/sina-weibo-users-facts-marketers/.
[40] ITU, *Yearbook of Statistics - Telecommunication/ICT Indicators - 2002-2011*, 38th ed. (International Telecommunication Union, 2012).
[41] FBI NW3C, "2012 Internet Crime Report," (FBI-National White Collar Crime Center, 2012).
[42]Heinzelman and Waters, "Crowdsourcing crisis information in disaster-affected Haiti.", p. 4
[43] Tim Leberecht, "Twitter grows up in aftermath of Haiti earthquake," http://news.cnet.com/8301-13641_3-10436435-44.html.
[44] Fiona MacGregor, "Rakhine aid workers resigning over social media threats," *Myanmar Times* 2013.
[45] Manuel Roig-Franzia, "Mexican Drug Cartels Leave a Bloody Trail on YouTube," *Washington Post* 2007.
[46] Tlanonotsalistli, "Mexico: Lethal Threats for Citizens Reporting on Drug Crimes," in *Global Voices Advocacy* (Global Voices Online, 2013).
[47] Nick Parker, Greg Botelho, and Rafael Romo, "Six tested for radiation now face questions in Mexico radioactive theft," CNN, http://www.cnn.com/2013/12/06/world/americas/mexico-radioactive-theft/index.html.
[48] Kwak et al., "What is Twitter, a social network or a news media?".
[49] D. J. Watts and P. S. Dodds, "Influentials, networks, and public opinion formation," *Journal of consumer research* 34, no. 4 (2007).
[50] M. Cha et al., "Measuring user influence in twitter: The million follower fallacy" (paper presented at the 4th International AAAI Conference on Weblogs and Social Media (ICWSM), 2010).
[51] Robert M. Bond et al., "A 61-million-person experiment in social influence and political mobilization," *Nature* 489, no. 7415 (2012).
[52] Jeff Howe, "Wired 14.06: The Rise of Crowdsourcing," *Wired* 2006.
[53] D.C. Brabham, "Crowdsourcing as a model for problem solving an introduction and cases," *Convergence: The International Journal of Research into New Media Technologies* 14, no. 1 (2008).
[54] Lee and Zolotova, p. 48.
[55] J. Surowiecki, *The Wisdom of Crowds: Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations* (Knopf Doubleday Publishing Group, 2004)..
[56] Christian Wagner and Tom Vinaimont, "Evaluating the Wisdom of Crowds," *Issues in Information Systems* XI, no. 1 (2010).
[57] Christopher M. Ford, "Twitter, Facebook, and Ten Red Balloons: Social Network Problem Solving and Homeland Security," *Homeland Security Affairs* 7(2011).
[58] Rutherford Iyad Rahwan et al., "Global manhunt pushes the limits of social mobilization," *Computer* 46, no. 4 (2013).
[59] D.C. Brabham, "The Myth of Amateur Crowds," *Information, Communication & Society* 15, no. 3 (2012).
[60] KR Lakhani et al., "The value of openness in scientific problem solving," (Working Paper, 07-050. Harvard Business School, Boston, MA, 2006).
[61] Nikolay Archak, "Money, glory and cheap talk: analyzing strategic behavior of contestants in simultaneous crowdsourcing contests on TopCoder. com" (paper presented at the Proceedings of the 19th International Conference on World Wide Web, 2010).
[62] Maria J Antikainen and Heli K Vaataja, "Rewarding in open innovation communities–how to motivate members," *International Journal of Entrepreneurship and Innovation Management* 11, no. 4 (2010).
[63] D. Geiger et al., "Managing the crowd: towards a taxonomy of crowdsourcing processes" (paper presented at the Proceedings of the 17th Americas Conference on Information Systems, Detroit, 2011).
[64] Thomas Malone, Robert Laubacher, and Chrysanthos Dellarocas, "Harnessing Crowds: Mapping the Genome of Collective Intelligence," in *MIT Sloan Research Paper No. 4732-09* (2010).

[65] Usama Fayyad, Gregory Piatetsky-Shapiro, and Padhraic Smyth, "From Data Mining to Knowledge Discovery in Databases," *AI Magazine* 1996.
[66] Maurice de Kunder, "The size of the World Wide Web (The Internet)," http://www.worldwidewebsize.com/.
[67] Michael K Bergman, "The deep web: Surfacing hidden value," *Journal of Electronic Publishing* 7, no. 1 (2001).
[68] Gabor Melli et al., "Top-10 Data Mining Case Studies," *International Journal of Information Technology & Decision Making* 11, no. 02 (2012).
[69] Bertis B Little et al., "Collusion in the US crop insurance program: applied data mining" (paper presented at the Proceedings of the eighth ACM SIGKDD international conference on Knowledge discovery and data mining, 2002).
[70] Nicolas P Maille et al., "What Happened, and Why: Toward an Understanding of Human Error Based on Automated Analyses of Incident Reports," (2006).
[71] Don R Swanson, Neil R Smalheiser, and Abraham Bookstein, "Information discovery from complementary literatures: categorizing viruses as potential weapons," *Journal of the American Society for Information Science and Technology* 52, no. 10 (2001).
[72] Malcolm Gladwell, "Small change. Why the revolution won't be tweeted," *The New Yorker* 4(2010).
[73] Allison June-Barlow Chaney and David M Blei, "Visualizing Topic Models" (paper presented at the ICWSM, 2012).
[74] Andrew McCallum, "Information extraction: Distilling structured data from unstructured text," *Queue* 3, no. 9 (2005).
[75] Bo Pang and Lillian Lee, "Opinion mining and sentiment analysis," *Foundations and trends in information retrieval* 2, no. 1-2 (2008).
[76] Johan Bollen, Huina Mao, and Xiaojun Zeng, "Twitter mood predicts the stock market," *Journal of Computational Science* 2, no. 1 (2011).
[77] S. Asur and B.A. Huberman, "Predicting the future with social media," *arXiv preprint arXiv:1003.5699* (2010).
[78] Ryan Compton et al., "Detecting future social unrest in unprocessed Twitter data:"Emerging phenomena and big data"" (paper presented at the Intelligence and Security Informatics (ISI), 2013 IEEE International Conference on, 2013).
[79] Nancy A Chinchor et al., "Multimedia analysis+ visual analytics= multimedia analytics," *Computer Graphics and Applications, IEEE* 30, no. 5 (2010).
[80] Charlie Savage, "Facial Scanning Is Making Gains in Surveillance," *New York Times*, 20130821 2013.
[81] Michael S Lew et al., "Content-based multimedia information retrieval: State of the art and challenges," *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMCCAP)* 2, no. 1 (2006).
[82] Joshua Pollack, "North Korea's ICBM Unveiled," *Arms Control Wonk* (2012), http://pollack.armscontrolwonk.com/archive/3932/north-koreas-icbm-unveiled.
[83] Pollack, "North Korea's ICBM Unveiled," http://pollack.armscontrolwonk.com/archive/3932/north-koreas-icbm-unveiled. Commenters on the blog *Arms Control Wonk* worked together to analyze parade footage from April 15, 2012. They quickly identified the WS51200 vehicle and posted announcements about the sale of the vehicles.
[84] United Nations, "Report of the Panel of Experts Established Pursuant to Resolution 1874 (2009)," S/2013/337, June 11, 2013, http://www.un.org/ga/search/view_doc.asp?symbol=S/2013/337, pg. 80. Annex XII includes a copy of the end-user certificate received by China.
[85] United Nations, S/2013/337, http://www.un.org/ga/search/view_doc.asp?symbol=S/2013/337.
[86] Yoshihiro Makino, "Chinese Shipper May Have Ties to N. Korean Arms Dealer," *Asahi*, June 25, 2012, http://ajw.asahi.com/article/asia/china/AJ201206250007. Asahi later obtained documents that suggested from the second shipment of 4 vehicles in October 2011. It would not be unusual to pay 6 million RMB each for the first two vehicles, then less for the next installment of four (18 million RMB total).
[87] "中国航天科工研制成功国内最大越野运输车 [CASIC Successfully Develops Country's Largest Off-road Vehicles," State-owned Assets Supervision and Administration Commission of the State Council of the People's Republic of China, May 26, 2011, http://www.sasac.gov.cn/n1180/n1226/n2410/n314319/13551197.html; Note: Hubei Sanjiang Space Wanshan Special Vehicle Co. Ltd took down its announcement: http://www.wstech.com.cn/en/show.asp?id=734.
[88] "九院：首次获大型非公路运输车批量出口订 [China Sanjiang Space Group (9th Academy): First Order of Heavy-Duty Off-Road Trucks]," China Aerospace Science & Industry Corp., October 19, 2010, http://www.casic.com.cn/n16/n1115/n2888/548509.html.

[89] Michael Madden, "DPRK Documentary Film Shows Kim Jong Il Inspecting Nodong, KN-08 Missiles," *North Korea Leadership Watch*, August 28, 2013, http://nkleadershipwatch.wordpress.com/2013/08/28/dprk-documentary-film-shows-kim-jong-il-inspecting-nodong-kn-08-missiles.
[90] "How Google Earth Images Are Made," Shashdot, 2006, http://science-beta.slashdot.org/story/07/04/30/0237218/how-google-earth-images-are-made.
[91] "Astrium," http://www.astrium.eads.net.
[92] 高青松 中根悠 [Chonson Ko and Yu Nakane], 金正日の秘密兵器工場：腐敗共和国からのわが脱出記 [Kim Jong Il's Secret Weapons Factory]. 東京 [Tokyo]: ビジネス社 [Bijineshusha], 2001.
[93] *The Gazetteer* is available online at: http://earth-info.nga.mil/gns/html/namefiles.htm.
[94] Stephen K. Lwanga, "EPI Coverage Evaluation Survey – 2008, Democratic People's Republic of Korea," UNICEF, December 2008, http://dev.undprk.matth.eu/content/uploads/2012/04/EPI-Coverage-Evaluation-Survey-2008-DPR-Korea-Final-Report.pdf.
[95] SAMs are frequently identified on www.wikimapia.org, http://geimint.blogspot.com, and www.nkeconwatch.com/north-korea-uncovered-google-earth, because their distinctive shapes are easily recognizable.
[96] KN-08, launcher, and TEL models courtesy of Frank Pabian.
[97] Reproduced by permission from Astrium and color corrected by CNS. Image: 12JAN10023602-S2AS-053264218020_01_P001
[98] Rahwan et al., "Global manhunt pushes the limits of social mobilization."
[99] Nathan Petrashek, "Fourth Amendment and the Brave New World of Online Social Networking, The," *Marq. L. Rev.* 93(2009).
[100] Firas Khatib et al., "Crystal structure of a monomeric retroviral protease solved by protein folding game players," *Nature structural & molecular biology* 18, no. 10 (2011).
[101] William Potter et al., "The CW Revolution will be Tweeted," James Martin Center for Nonproliferation Studies, http://cns.miis.edu/stories/130912_cw_revolution_tweeted.htm.