VERIFICATION TECHNOLOGY RESEARCH AND DEVELOPMENT NEEDS

The following represents the priority needs of the Bureau of Arms Control, Verification and Compliance (AVC) for research and development programs to address critical arms control and nonproliferation technology requirements in the realm of verification and transparency. Responding to these priorities may involve the use of current technologies in unconventional ways, while others will require years of basic research, a properly resourced transition and acquisition process to build deployable systems, and diplomatic legwork on our part to create a feasible environment for deployment.

To better categorize our priorities, we have divided the document into two sections. The first is Support for the Present Generation of Treaties, Agreements, and Initiatives. The second is Exploratory Research to Lay the Groundwork for Future Options in Arms Control and Transparency.

SUPPORT FOR THE PRESENT GENERATION OF TREATIES, AGREEMENTS AND INITIATIVES

Missiles and Nuclear Arms Reduction

The New START Treaty has a verification regime in which National Technical Means (NTM) play a significant role. The Intermediate-Range Nuclear Forces (INF) Treaty also remains in force. While the inspection regime for the INF Treaty has expired, Section 403 of the Arms Control and Disarmament Act (22 U.S.C. 2577) requires yearly compliance reporting.

Verifying compliance with central commitments in the New START and INF Treaties as well as potential future agreements regarding reductions in and elimination of non-strategic nuclear weapons and non-deployed nuclear weapons requires extensive collection of detailed monitoring information. Such information also supports informed U.S. participation in Treaty implementation commissions (such as the New START Treaty's Bilateral Consultative Commission and the INF Treaty's Special Verification Commission). Topics:

- Assessing the accuracy of information provided by states (telemetry, data exchanges, database declarations, etc.).
- Upholding and defending U.S. verification rights and assets (inspection rights, NTM non-interference and countering vulnerabilities).
- Increased awareness of high-tech systems that other powers may develop, which exploit vulnerabilities in our current sensor systems.
- Detecting development, manufacture and deployment of mid-tech systems

The Nuclear Non-Proliferation Treaty

In April 2009, the President outlined his nuclear security strategy in Prague. He indicated that the Administration would work to strengthen the Nuclear Non-Proliferation Treaty (NPT). This initiative will require improved capabilities to detect and characterize activities associated with the nuclear fuel cycle and with nuclear weapon development. Topics:

- Improved means to detect non-compliance with the nuclear nonproliferation treaty

Nuclear Test Ban Treaties, Agreements, and Moratoria

In outlining his nuclear security strategy in Prague, President Obama indicated that the Administration would work for the ratification of the Comprehensive Test Ban Treaty (CTBT). Other test ban treaties are already in force, including the Limited Test Ban Treaty (LTBT), the Threshold Test Ban Treaty (TTBT) and the Peaceful Nuclear Explosion Treaty (PNET). Section 403 of the Arms Control and Disarmament Act (22 U.S.C. 2577) requires yearly compliance reporting on such treaties.

While global explosion monitoring technology is mature, several factors serve to drive the need for ongoing research to upgrade and refine our capabilities in this area. We cannot effectively manage risk associated with the test moratorium and eventually the CTBT by resting on our laurels. Challenges include ever improving foreign denial and deception capabilities to impair collection. As a result we will need to be able to detect much lower yields (well within the power of conventional explosions), to counter the use of evasive techniques in areas inaccessible to regional monitoring sites (less than 200 kms away), and finally to distinguish between very low yield nuclear events versus conventional explosions. Enabling research needs to be performed to enhance understanding of the underlying physical phenomena, to develop new collection instruments and data exploitation techniques, and to develop ways to exploit new signatures associated with nuclear testing. The State Department's Berkner Panel Report of 1959[1] still provides good guidance concerning the key research areas (source phenomena, wave propagation, better detection, and better data processing techniques; specific subtopics have of course changed over the last half century). Topics:

- Determining whether a nuclear explosive test has occurred

[1] Fifty years ago the Berkner Panel report led to the creation of the ARPA-funded World-Wide Standardized Seismograph Network (WWSSN), which among other things led to the confirmation of plate tectonics, using year-long recordings of analog seismic data. Today's IMS or USAEDS can do that with just a month-worth digital data. But there is no doubt there is still a need to do research on better, smaller, more rugged seismic and acoustic sensors.

- Improved seismic detection, identification and characterization of underground explosions.

- Tools and technologies to provide data and a detailed in-depth post-event analysis for events of verification concern, such as declared or suspicious foreign nuclear tests, to include raw seismic data from USAEDS, IMS, USGS, and other networks. We also need to detect and identify possible tests conducted underwater, in the atmosphere, and in outer space.

- Capability to rapidly determine whether an explosion is nuclear or conventional.

For a CTBT On-Site Inspection (OSI), allowable inspection activities and techniques[2] are at various degrees of maturity. Opportunities such as the OSI Integrated Field Exercise in 2014 should motivate accelerated progress in further developing and fielding the wide variety of allowable inspection activities and techniques.

In addition, the CTBT provides that detection and characterization of radionuclides during OSI can be limited to only radionuclides relevant to the OSI. An agreed list of radionuclides considered "relevant" has been arrived at in the CTBT Preparatory Commission. Accurate and useful determination of the presence and abundance of these relevant radionuclides generally requires acquisition of full gamma-ray spectra containing information about radionuclides present that are not on the "relevant" list. Research is needed to explore the feasibility of "information barriers" either by development of reliable and sufficient analysis techniques that can work with only partial spectra or the development of software/hardware solutions to allow the collection and analysis of complete spectra without making the full spectral data (or information about non-"relevant" radionuclides) available to inspectors.

Biological Weapons Convention

Current policy initiatives are primarily derived from the National Strategy for Countering Biological Threats (Strategy), the National Security Strategy and the Quadrennial Diplomacy and Development Review. The Strategy, in particular, tasks the U.S. government to pursue capabilities in seven key areas to protect the homeland and its citizenry from natural or manmade biological threats. Within those seven areas are specific calls for technological developments or improvements, notably: building knowledge as to the global disease burden and technological capabilities; improving intelligence on deliberate biological threats; facilitating data sharing and knowledge discovery; ensuring robust capabilities for law enforcement and security; ensuring robust capabilities to disrupt or interdict illicit activity; and, enhancing microbial forensics and attribution.

[2] Paragraph 69 of the CTBT Protocol

The provisions of the Biological Weapons Convention (BWC) prohibit offensive biological weapons programs. Topics:

- Means and methods to discriminate problematic biological activities from genuinely defensive programs or benign research.
    - Rapid technical assessments to determine if observed activities have a credible justification for prophylactic, protective, or other peaceful purposes.
    - Innovative ways to improve transparency of biodefense research activities.
- Evidence of proliferation alliances to develop biological weapons.

In addition, AVC is tasked with providing international coordination for any investigation of attribution of use involving a pathogen. This requires the ability to detect both use and attribution.

Chemical Weapons Convention

Current policy initiatives and priorities are primarily derived from National Security Directives and implementation directives for the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction. The Treaty eliminates an entire category of Weapons of Mass Destruction through its prohibitions and application of strict verification measures. Through its non-proliferation mandate and verification regime, the Treaty seeks to ensure that toxic chemicals and precursors are only used for purposes not prohibited by the Treaty. It is critical to maintain the ability to verify compliance with this Treaty in the face of advances in the chemical industry, and science and technology. Topics:

- Capabilities to detect unreported dual-use activities regulated under the Chemical Weapons Convention (CWC), indicators of possible intent to circumvent CWC prohibitions and indicators of possible violations in relation to chemical technology and equipment.
- Updated risk assessments to evaluate advances in global dual-use technologies for the civilian chemical industry that have application to chemical weapons (CW) programs.
    - Advances in chemical synthesis and analytical methodologies.
    - Advances in materials science, e.g., nanotechnologies.
    - Advances in chemical-biological crossover technologies.

  - Advances in the miniaturization of plant technologies such as micro-reactors.
  - Tech watch for next generation, commercially available, detection and sensor monitoring capabilities, particularly those that might complicate a violator's ability to find and suppress signatures associated with a covert program.

- Indicators of possible material violations of the CWC.
- Detect transfer of weapons and Schedule 1 chemicals or precursors and other toxic chemicals.
- Geo-location history of material, containers, or documents related to chemical weapons.
- Detect weaponization (includes production and processing related to weaponization).
- Detect weapon testing (air monitoring, soil sample testing, imagery, etc.).
- Tools and techniques to support sampling and analysis of chemical agents and their degradation products in a variety of matrices and environments.
- Equipment allowing more rapid sampling and analysis in the field.
- An updated assessment and evaluation of advances in calmatives and incapacitating chemicals.
- Assess likelihood for military (CW) applications.
- Determine development and /or production facilities.
- Detect employment for law-enforcement, antiterrorist and other sub-military actions.

Conventional Arms Control

Current policy initiatives are primarily derived from National Security Directives and implementation directives for the Treaty on Conventional Armed Forces in Europe. The Treaty eliminated the enormous conventional forces disparity that existed between East and West during the Cold War. Combined with other developments in Europe, the Treaty impedes the ability of any State Party to conduct large-scale offensive action on short notice, and lays the foundation for the modern European security architecture. It will be critical to maintain the ability to verify compliance with this Treaty as long as it remains in force and future conventional arms control agreements in the face of technological advances. Topics:

- Verifying compliance with conventional arms control agreements such as the Conventional Armed Forces in Europe Treaty (CFE)

- Maximizing benefits from verification regimes like Open Skies.

- Rapid and accurate identification, classification, and counting of equipment observed in the field[3].

Open Skies

There is a need for sensors (digital video, IR and SAR) that meet the criteria outlined in the Treaty on Open Skies and its subsequent Decisions, ensuring aerial observation of all the territories of the parties to the Treaty. The Treaty allows the United States to deploy digital video, infra-red and synthetic aperture radar sensors on-board the aircraft, all of which would be an improvement over the antiquated wet-film optical cameras currently being used. Such capabilities may in the future help support expanding verification goals.

U.S. National Space Policy

The National Space Policy released in June 2010 says that the United States will consider space-related arms control concepts and proposals that are equitable, effectively verifiable, and enhance the national security of the U.S. and its allies. The Administration is also expanding its efforts in international cooperation in space activities and conducting expedited reviews of key issues, such as long term sustainability of space activities and orbital debris mitigation that will require improved space situational awareness. Topics:

- There is an ongoing need to further develop measures to verify the ban on WMD in space, and the prohibitions on interference with National Technical Means.
- New tools and technologies are required to improve our ability to assess and monitor possible violations of the Outer Space Treaty's ban on WMD in space.

Many arms control treaties contain clauses that prohibit interference with National Technical Means (e.g., New START, Moscow Treaty, INF, CWC, CTBT, and LTBT). It would be useful to have expanded means and methods to detect violations of these treaty obligations and indicators of intent to violate the obligations, including indications of development, testing and deployment of anti-satellite weapons.

- Verify compliance with CTBT and LTBT provisions prohibiting nuclear tests in space.

The Administration is pursuing transparency and confidence building measures to promote safe, responsible, and peaceful behavior in space. For example, the United States is

[3] With rapid advance of weapons technologies and inherent limitations on equipment definitions and reporting systems, such accounting becomes more essential to the effective verification of treaties and agreements.

working with the EU and interested countries on an international "Code of Conduct for Outer Space Activities." We cannot develop and promote new space arms control concepts and proposals if we cannot monitor compliance. As we consider initiatives to further define "rules of the road" for behavior in space, we need to dramatically step our game on space object situation awareness. In particular, if we are to have a space conduct control regime, we need to detect and attribute a wide range of prohibited behavior by possibly very small satellites of unknown provenance at orbits as distant as GEO. We need to understand the "art of the possible" in this regard.

Although it will be politically binding only, the proposed international "Code of Conduct for Outer Space Activities" will require an improved ability to detect and monitor the activities of satellites, actions taken against satellites, and debris fields in space. This ability may also contribute to ongoing U.S. activities in various international fora concerned with orbital debris monitoring and mitigation. Topics:

- The ability to be able to monitor interference with non-NTM satellites (e.g., other national security, civil, commercial space)
- To detect and attribute "bad behavior" and irresponsible activities that do not immediately and noticeably degrade or interfere with our satellites (such as parking a small satellite close to another satellite or even latching on to it). When we see ambiguous activity in space such as close encounters between our satellites and space debris, can we divine their intentions?

EXPLORATORY RESEARCH TO LAY THE GROUNDWORK FOR FUTURE OPTIONS IN ARMS CONTROL AND TRANSPARENCY

Existing verification and transparency strategies are by themselves insufficient to address all the challenges that are likely to be posed by the arms control and transparency initiatives of the future. Possible future arms control and transparency regimes, such as for nuclear warhead reductions, may involve issues that do not easily lend themselves to monitoring by currently available inspection tools and NTM capabilities. New challenges will arise as nuclear arms control advances along the "road to zero." We need to be able to detect and monitor smaller items of inspection, and quantities of controlled materials, warheads and delivery systems. Further complicating the picture, more players may come under the umbrellas of verification regimes. Verification technologies are the linchpin of the arms control process. The inability to verify constrains policymakers' options but new technologies can provide game-changing enhancements to our ability to verify.

Future Nuclear Arms Reduction and Fissile Material Cutoff Treaties

In April 2009, the President outlined a long term goal of a world free of nuclear arms. The "road to zero" will be long. The negotiations on future treaties to further reduce nuclear weapons may move away from the traditional focus on strategic delivery systems and towards limits on nuclear warheads[4].

Verification of treaties that directly address nuclear warheads will require new approaches that balance the need to protect sensitive information with the inherent difficulty of remotely detecting nuclear devices. We need to develop the best possible technologies to mitigate the difficulties associated with striking this balance. Topics:

- Tools for verifying the presence or absence of nuclear weapons.
    - Acknowledging the extensive R&D work that has taken place to date, the demonstration of a fully authenticable information barrier Radiation Detection Equipment.
    - Additional research into methods and technologies that intrinsically protect classified information.

To enable this work will require a better understanding of the information the United States and other potential treaty partners may determine requires protection. This includes understanding the range of possibilities when providing information to another nuclear weapons state under the NPT versus a non-nuclear weapons state. Topics:

[4] When President Obama signed the New START Treaty in April 2010, he stated his intention to pursue new reduction negotiations that would involve non-deployed and non-strategic warheads in addition to deployed systems, i.e. warheads mated to their delivery vehicles.

- Improved tools to assure continuity of chain of custody of a nuclear device. Specifically, once an item has been inspected and /or catalogued, we want to be sure that it stays that way.

- Improved tools and processes for authenticating chain of custody for equipment used to verify non-nuclear objects and weapons.

    - New means to identify tampering.

Advanced tools and technologies to support implementation of possible future fissile material control regimes, such as the proposed Fissile Material Cutoff Treaty (FMCT). A broad series of technical approaches should be considered, including but not limited to tags and seals, radiation measurements, and other ways to detect and characterize nuclear activity, equipment, and materials. Topics:

- To develop an optimum mix of technology and access regimes to detect fissile materials in transit.

- Sharable detectors of controlled nuclear materials.

New technologies will also be needed to:

- Permit attribution of nuclear materials.

    - Sharable methods of tagging and fingerprinting materials.

- Monitor and characterize nuclear equipment

We need to create an infrastructure to support international joint development of technologies to support verification of nuclear disarmament, including effective verification of a Fissile Material Cut-off Treaty (FMCT)[5]. Specifically, we need to establish joint initiatives on

- Development of Technical Guiding Principles
- Radiation Technology
- Remote Monitoring Technology
- Chain of Custody
- Possible Experiments and Demonstrations.

Strategic weapons controls and reductions have traditionally been addressed by bilateral US/Russian treaties covering delivery systems (such as New START), while the nuclear industry

[5] Such efforts support two goals. In an era of shrinking resources, it makes sense to pool resources. Secondly, many countries are more willing to trust information developed by jointly-developed verification assets than they would to trust data coming from assets developed exclusively by the United States.

has been addressed by the multi-lateral Nuclear Non-Proliferation Treaty (NPT). The proposed Fissile Material Cutoff Treaty would more broadly address key nuclear materials. Regimes that address the full lifecycle of nuclear warheads and their components will likely have to merge functions that have historically been addressed by these separate treaties. Conceptual designs for such cross-cutting control regimes need to be developed. To do so, the expert community will need to identify chokepoints and possible new signatures that might be useful to a new generation of control or transparency regimes.

- Research is needed for the uncharted territory of a P-5 treaty. The tools and techniques will need to take into account that countries such as China will not wish to accept intrusive measures in a first such treaty. The limitations are most likely to focus on delivery systems.

- We need to refine our understanding of the nuclear warhead life cycle and to promote the emergence of new options for verifiable nuclear arms reduction and /or transparency regimes.

Ubiquitous Sensing: Using Sensors on Widely Dispersed Platforms

We are looking for new observables that could be incorporated into future arms control and transparency regimes. We are also seeking ICT technologies to provide near real-time information to inspectors in the field.

Ubiquitous sensing may contribute to a new generation of safeguards and nonproliferation technologies. For example, it may be used to enable constant measurement of all nuclear materials at all times[6].

- Develop seals and tags that can be widely dispersed, read remotely by inspectors at a distance, and are trusted by both the hosting and inspecting parties.
    - Sensors to detect presence of fissionable materials.
    - Sensors to verify quantity of fissionable material present.
    - Sensors to detect tampering and provide integrity assurance of monitored equipment.
- Understand how ubiquitous sensing impacts the overall proliferation regime.

The proliferation of mobile devices and the emerging internet of things are already creating an ambient environment permeated with sensors, and we need to understand how these technologies may impact arms control. Topics:

[6] This formulation follows William Charlton at Texas A&M.

- Understand and adapt the internet of things (IOT) to support arms control goals such as transparency and data assurance for feeds from verification sensors[7].
    - Arms control applications for information assurance
    - "Identity verification" technologies originally developed to support the IOT.
    - Encrypted IOT traffic to be unlocked later for spot compliance checks. This could lead to new classes of signatures that could be monitored and regulated under future arms control regimes.

Mobile devices such as smart phones and tablets may serve as sensor platforms, as communications hubs connecting humans and ambient sensor networks, and as tools for managing information on location and in real-time. We need to develop safeguards/verification applets that could be installed on mobile devices carried by inspectors. Topics:

- Understand the data already collected by mobile devices and see whether applets can be written to adapt these capabilities to support inspections.
- Connect all safeguards/verification sensors in an inspected facility wirelessly to the inspector's mobile device.
- Employ the use of specially designed quick response (QR) codes to rapidly decode and track munitions, warheads or smaller items using smart media.
- Access in real-time virtual models of a facility while it is being inspected (assuming adequate broadband connectivity).
- Develop a suite of apps that might be in an inspector's toolbox, including for example functions such as scanning, reading and translation of text; access to previous site reports, site diagrams and photos; real-time reports on environmental conditions; inspection logistics support (general travel needs and coordination); and mission planning software.

[7] The "internet of things" is a term for an emerging internet where everyday objects (household appliances, thermometers, lights, cars and their components) are connected to the internet and are able to directly communicate and cooperate with one another. For example, in one scenario posted in a blog on the internet (http://blogs.cisco.com/news/the-internet-of-things-infographic/), your meeting might be pushed back 45 minutes, telling your alarm clock to give you an extra five minutes of sleep, which then tells your coffee maker to start making coffee five minutes later as well. It might also check the weather and tell your car to start in 5 minutes to melt the ice accumulated overnight in a snow storm. The internet of things is already five times larger than the internet we use every day: ATM and all banking transactions, medical data, shipping data, telemetry and tracking data are all examples.

Expanding the Open Skies Paradigm

Two transparency concepts first proposed in the 1950s may play an increasing role in the arms control regimes of the future: the cooperative aerial reconnaissance regime and "public technical means."

The Open Skies Treaty has established the precedent for cooperative aerial reconnaissance regimes. Topics:

- Exploratory thinking on possible ways to apply the Open Skies concept to a variety of difficult to monitor nuclear, chemical and biological agreements.
- Identification of releasable technologies to exploit access based on the Open Skies concept and design of aerial access regimes that reflect these technical opportunities[8].
- Removable ("roll-on, roll-off") sensor systems that allow different aircraft to be deployed in multiple scenarios.

Embracing Public Technical Means

Public Technical Means includes data, interactions and analysis in the public domain. This includes "societal verification," which is evolving from its initial definition of individuals taking responsibility to report treaty violations to include aggregate activities involving highly empowered citizens carrying "smart phones" and sharing information across social networks and the resulting crowd interactions[9]. This will likely be a game changer in many areas and arms control will probably not be the leading adopter[10], but it this emerging interaction between people and technology could help empower a new generation of transparency measures and arms control verification provisions. We need to understand the underlying phenomena to assess possible paths forward.

Develop Understanding of the Ethical and Legal Issues Involved: We need research into the ethical and legal issues posed by the use of citizen sensors, social media and crowd sourcing

[8] Generally, commercial off-the-shelf technologies are most suited for such missions. Depending on the context, there may also be a role for newly developed or custom-built technologies, but it will need to be assumed that non-U.S. nationals will have access to the equipment and that all Treaty parties will have access to the data.

[9] This language is taken from Stubbs and Drell.

[10] Given the complex ethical and legal questions involved, communities addressing topics such as climate change and disaster relief will likely take the lead in employing information obtained from citizen sensors and social media, but the arms control community needs to be fully aware of the emerging norms in this area to lay the groundwork for the creative use of such public technical means in the context of future arms control and transparency initiatives. Active research will be needed to develop an understanding of the full range of issues that need to be addressed and resolved before such tools are deployed.

to further a diplomatic and national security goal such as arms control and its related transparency measures. Topics:

- What are the ethics of, and appropriate tradecraft for a government reaching out to its own population through the use of citizen sensors, social media and grand challenges? What are the legal issues?
- What are the ethics of reaching out to foreign populations? What are the legal issues?
- We need to keep abreast of the emerging expectations, ethics, and legal issues associated with the use of aggregate information in the public domain for purposes such as arms control verification.
- We need to support and actively participate in conceptual design work for the institutional framework to oversee and regulate the use of citizen sensors, social media and crowd sourcing.

Tools for Information Discovery: We need to assess and fully understand the possible future utility of social media in developing information that could be useful in arms control contexts. Some areas to be explored may include:

- The continuing viability of social media and networking as a popular medium for the free flow of information.
    - As government or other regulations take hold in some settings, are there stable workarounds? Are there stable and effective counters to efforts to constrain or undermine information flow?
    - What are the relative virtues and limitations of tweets, photos and videos for information discovery; and to what extent will the new media supplant or supplement such methods of reporting?
- What are the roles of moderators and /or network nodes in shaping the discourse in social media and efforts to influence or constrain information flow?
- Tools to screen and provide alerts to incorrect information that appears on networks.
- Understanding the use of public incentives in conjunction with social media to develop information (such as the DARPA Red Balloon Challenge[11]).

[11] The 2009 DARPA Red Balloon Challenge explored how incentive-based social networking might be used to crowd source problem-solving. A $40,000 award was promised to the first team to locate all ten red weather balloons tethered at locations somewhere in the continental United States. The MIT Team won by pursuing a social networking strategy where the prize money was distributed to participants that facilitated successful balloon

- Are systems such as Amazon's Mechanical Turk system useful to gather and analyze social media data[12]?

- What might be the means and methods to engage concerned citizens to employ new information technologies and social media in support of arms control and transparency efforts[13] (e.g., verification challenges)?

Tools to Supplement Analysis of Existing Information: There is a continuing need for the development of new analytic tools that can collect information from a wide variety of sources, collate that information into user-defined categories, and display the information in ways that can be analyzed for better understanding. This may include information from traditional intelligence sources, but also information from open source resources and non-traditional sources, including some of the "social network" applications. Examples may include, but are not limited to:

- Visual analytics and other new information technologies to aid analysts in identifying, extracting, and connecting crucial facts from a deluge of disparate data streams and integrating them into a coherent picture.

- Data fusion to improve sensor performance or queuing. For example, data fusion may be used to lower detection thresholds for problem areas in which large numbers of false positives pose a challenge.

- 3-D modeling software to support individual characterization and visualization (including interiors) of buildings and facilities to support facility analysis in a virtual way or provide memory aids for inspectors.

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sightings (following a sliding scale with the highest amounts going to those who themselves spotted a balloon and lesser amounts going to members of the referral chain that led to the balloon spotter).

[12] The *Amazon Mechanical Turk* is an Internet marketplace that gives *Requesters* (usually businesses) the ability to crowd source tasks (known as *HIT*s or *Human Intelligence Tasks*). Typical *HIT*s might involve choosing the best among several photographs of a store-front, writing product descriptions, or identifying performers on music CDs. Solution *Providers* can then browse among existing tasks and complete them for a monetary payment set by the *Requester*. *Requesters* pay 10 percent over the price of successfully completed *HIT*s to *Amazon.com*, the site host. The name *Mechanical Turk* comes from "The Turk," a chess-playing "automaton" of the 18th century. It was later revealed that this "machine" was not an automaton at all, but was in fact a chess master hidden in a special compartment controlling its operations. Likewise, the *Mechanical Turk* web service allows humans to help the machines of today perform tasks for which they are not suited.

[13] Concerned citizens have already employed social media to find people trapped in buildings or rubble following natural disasters (e.g., the Haiti earthquake) or to solve environmental cleanup problems due to industrial accidents (e.g., the Gulf oil spill). Some of these techniques could be also used, for example, to identify a disease outbreak in a remote area.

- Tools to exploit virtual globes and other forms of geospatial databases (e.g., applications that exploit Google Earth). This includes meta-search engines and viewers to put all the pieces together from Open Source GEOINT (e.g., member state information reported to international organizations, media reporting, commercial satellite imagery, wikis, social networks, blogs, NGO databases, Open Source Services).
    - Next-generation improvements to existing products such as GeoHack and GAIAGI.
    - New conceptual advances in this area.
- The role of thinking machines such as IBM's Watson to support analysis[14].
- Predictive analytics by humans and machines to determine event direction or alert to data that indicate event detection.
- Development of analytical tools for torrents of user-generated content (such as twitter feeds).
    - Gill-like tools to strain and analyze highly diluted information present on tweets, photos, videos.
    - Tools to examine, decipher, and analyze the temporal response of web activity, blogs and tweets.
    - Tools to make complex data generated by social media and web traffic quickly accessible to wider audiences (in particular policymakers).
    - Approaches making current analytical tools adaptable to evolving social media interfaces.

Facilitating the Activities of Public Verification Communities: We need to explore innovative methods to foster collaboration between NGOs, concerned citizens and government to support arms control goals.

- Develop the concept of public challenges to pursue further arms control policy research and development strategies.

[14] An early adoption of Watson-type intelligence to an area of AVC interest may be in the area of algorithms used to analyze symptoms in case of possible exposure to chemical, bio and bio-toxin agents. This application would address the "detect and treat" response to a possible chemical, biological or biotoxin accident or use incident. A machine like Watson could also be used to identify in a short space of time the most likely synthetic pathways that can employed to produce the most significant yields of a chemical or biological agent using non-traditional precursors.

- Develop arms control web portals, social media sites, and applets for the use of by NGOs and concerned citizens.
- Develop the concept of "public verification challenges[15]."

[15] Governments will have an interest in proving that they are meeting their arms reduction obligations and may want to engage their publics in helping them to make the case.