Article:

Robertson, David James and Burton, Anthony Michael orcid.org/0000-0002-2035-2084 (2016) Unfamiliar face recognition : Security, surveillance and smartphones. The Journal of the Homeland Defense and Security Information Analysis Center. pp. 14-21.

HDIAC Journal

The Journal of the Homeland Defense and Security Information Analysis Center

Volume 3 Issue 1 Spring 2016

SPECIAL OPERATIONS:

Leveraging Innovation to Improve Battlefield Performance

HDIAC
Homeland Defense & Security Information Analysis Center
JOURNAL
Volume 3 • Issue 1 • Spring 2016

Managing Editor: Jessica Hill
Graphic Designer: Jennifer Kruzic

About this publication: The Journal of the Homeland Defense and Security Information Analysis Center (HDIAC) is published quarterly by the HDIAC staff. HDIAC is a DoD sponsored Information Analysis Center (IAC) with policy oversight provided by the Assistant Secretary of Defense for Research and Engineering (ASD (R&E)), and administratively managed by the Defense Technical Information Center (DTIC). HDIAC is operated by Information International Associates (IIa) in Oak Ridge, Tenn. Reference herein to any specific commercial products, processes or services by trade name, trademark, manufacturer or otherwise, does not necessarily constitute or imply its endorsement, recommendation or favoring by the United States government or HDIAC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or HDIAC, and shall not be used for advertising or product endorsement purposes.

Department of Defense Information Analysis Centers

Contents

Contact HDIAC

Stuart Stough
HDIAC Director
sstough@hdiac.org

HDIAC Headquarters
104 Union Valley Road
Oak Ridge, TN 37830
(865) 535-0088

HDIAC Contracting Officer Representative/ Program Management Analyst
Josette H. Friedl (PMA)
DoD Information Analysis Centers
McNamara headquarters Complex, VA
Office: 703.767.9116
Email: josette.h.friedl.civ@mail.mil

DoDIAC Public Affairs Officer
Michele Finley
Office: 703.767.9122
Email: michele.l.finley2.civ@mail.mil

IAC Program Management Office (DTIC-I)
872 John J. Kingman Road, Suite 0944
Fort Belvoir, VA 22060-6218

Message from the Director:
Better Buying Power 3.0

The Homeland Defense and Security Information Analysis Center supports Better Buying Power 3.0, a Department of Defense initiative to achieve dominant capabilities through technical excellence and innovation. Incentivizing innovation in industry and government, one component of BBP 3.0, is focused on in this highlight.

HDIAC's various services, including the inquiry process, HDIAC Journal, website and Core Analysis Task, increases the government's return on and access to small business research and development. By providing customers with high quality information and analysis in its inquiry responses, HDIAC is able to help the government leverage small businesses with creative and innovative technologies to work with the DoD and have their technologies included in products the DoD acquires.

HDIAC recently received an inquiry from the United States Special Operations Command requesting information and analysis on medical mannequins with more realistic tissue structures to train special operations medics on combat wound treatment. The rigid plastic of traditional mannequins often makes it difficult to judge the appropriate pressure needed for treatment in the field.

Better Buying Power Focus Areas

1. **Achieve Affordable Programs**
2. **Control Costs Throughout the Product Lifecycle**
3. **Incentivize Productivity and Innovation in Industry and Government**
4. **Eliminate Unproductive Processes and Bureaucracy**
5. **Promote Effective Competition**
6. **Improve Tradecraft in Acquisition of Services**
7. **Improve the Professionalism of the Total Acquisition Workforce**

HDIAC analyzed SOCOM's unique technical requirements and options employed by the Department of Defense. Through research, HDIAC identified industry innovations that could provide enhanced medical mannequins to create realistic special operations medical trauma training. HDIAC's inquiry response made recommendations to SOCOM to improve training by employing medical mannequins with more accurate tissue, muscle and skin composition and biologically relevant materials.

Historically, soldiers and medics used human cadavers and animals for training. However, HDIAC's research showed there are options better suited for current military needs. HDIAC identified numerous companies developing medical mannequins that could suit SOCOM's needs. These companies are developing innovative products, including soft tissues, organs and skeletal systems, which SOCOM could utilize to better prepare medics for addressing combat injuries.

HDIAC's inquiry response provided an understanding of SOCOM's medical training needs and an overall awareness of easily modifiable options that meet those needs. Because of the inquiry response provided by HDIAC, SOCOM initiated relationships with industry partners.

HDIAC's analysis benefited SOCOM by providing alternative options to

Stuart Stough
HDIAC Director

current trauma training and increased knowledge of currently available capabilities and materials to create realistic tissues in training mannequins.

By engaging HDIAC in these areas, SOCOM learned of emerging technologies and was able to engage industry partners. Because HDIAC provided SOCOM an extensive understanding of industry capabilities, SOCOM was able to engage only those companies capable of meeting SOCOM's requirements, which eliminates unproductive process and bureaucracy. SOCOM's relationships with these partners will save money and resources because the government will not have to flow through its own research and development lifecycle to develop a usable product.

Furthermore, SOCOM will be able to take advantage of HDIAC's Core Analysis Task, a contract vehicle that incentivizes productivity and innovation in academia, government and industry and controls lifecycle costs.

EPA AND DHS PARTNER IN RADIATION DECONTAMINATION PROJECT

By: Gregory Sayles, Ph.D.

If a dirty bomb detonates or a nuclear power plant accident occurs, responders must be equipped to handle the resulting potential wide-area radiological contamination. Minimizing radiological contamination, protecting people and the environment, and restoring services to critical infrastructure is vital. Depending on the scope of the incident, the response could be costly, lengthy and pose numerous challenges to the resilience of the affected community. Having readily available mitigation and decontamination technology options will assist local, state and federal radiation responders to formulate a resilient response and recovery effort in the event of a radiological incident.

By taking advantage of timely, cost-effective mitigation options, early responders will mitigate radiological contamination, thus reducing dose and allowing continuity of response operations and public services. Federal environmental responders, on-scene coordinators and other officials need timely and cost-effective decontamination options, which will enable contamination responders to return cleanup sites to a usable state.

Not every technology will be applicable to a specific incident or available at a specific site when needed. Certain technologies are more effective, but not widely available; others are less effective, but more widely available.

To ensure decision-makers have a diverse technology toolbox, researchers at the U.S. Environmental Protection Agency, in collaboration with the Department of Homeland Security, conducted a wide-area urban radiological contaminant mitigation and cleanup technology demonstration. The event replicated an urban radiological incident in order to train researchers and local, state and federal decision-makers on how to determine appropriate containment, decontamination and recovery guidelines.

Researchers demonstrated a toolbox of options to mitigate and decontaminate urban, wide-area radiological contamination stemming from an event such as a dirty bomb detonation or nuclear power plant accident. While organizers did not use live radionuclides in this operational demonstration, they assessed all technologies for their cleanup efficacy using radionuclides in controlled laboratory settings. The demonstration marked the first large-scale testing of the technologies, identifying additional research gaps and transitioning research findings to the end-user community.

The operational demonstration examined a number of innovative solutions. The mitigation technology portion of the demo included building and vehicle decontamination technologies and particle and liquid containment strategies. Organizers also demonstrated five technologies for wide-area radiological decontamination, including chemical foam solutions, strippable coatings and gels. Wastewater treatment, a tool for waste management, was also demonstrated. Summaries of highlights related to these three elements follow.

Mitigation Technologies

To help combat the problem of tracking radioactive materials out of a contaminated area by foot or by vehicles, researchers used fluorescent particles to test materials that could potentially reduce the spread of contamination. Using chemical wash solutions with additives such as foam, local firefighters demonstrated how to wash radiological contaminants off an urban brick building and off vehicles potentially used by early responders.

Decontamination Technologies

Responders demonstrated gels and strippable coatings designed to trap radioactive contaminants and then peel, vacuum or wash off of buildings, thereby minimizing waste streams. These technologies were separately demonstrated on small sections of other urban materials, such as granite, marble and limestone, which are often found in urban building settings.

Waste Management

Waste management, a potential stumbling block during radiological response, was an important part of the demonstrations as well. A wastewater containment system coupled to a treatment trailer designed to treat wastewater was on-site. Treatment of wastewater during decontamination operations may be essential for reuse, as billions of gallons of water could be used if a large portion of a city is contaminated. Recycling water could lessen the burden on the city's water supply and potentially reduce the amount of radioactive wastewater to be disposed.

To see more about the demonstration please visit: https://youtu.be/IV7N-2jWm6js

For more information about this research, please visit: www.epa.gov/hsresearch

To learn more about our researchers:

- Dr. Sang Don Lee https://youtu.be/_MTpjh3OG6k
- Dr. Paul Lemieux https://youtu.be/-dHsAlmoC5Q

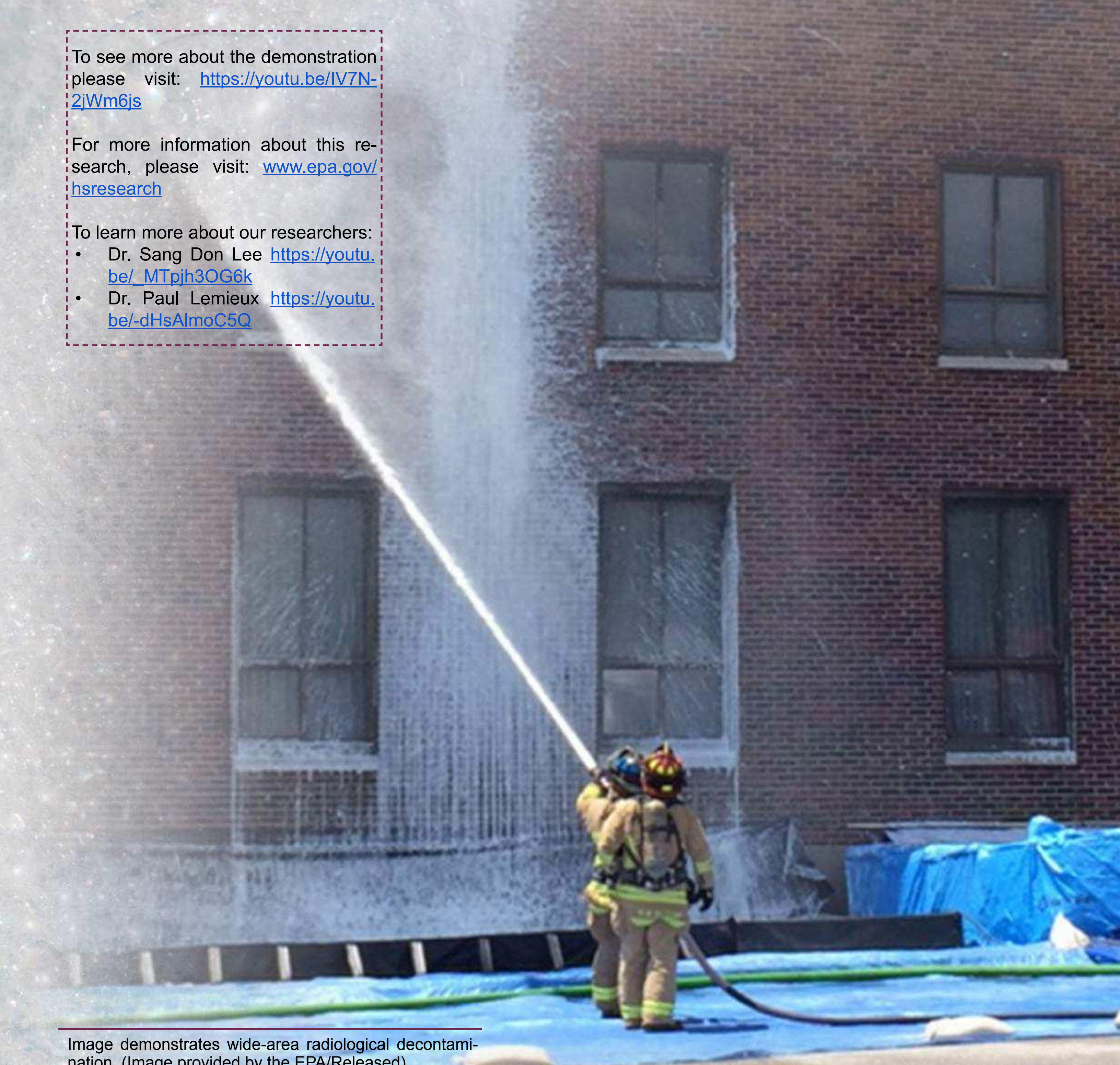


Image demonstrates wide-area radiological decontamination. (Image provided by the EPA/Released)

Dr. Gregory Sayles directs the EPA's homeland security research. The research program supports the EPA's mission by striving to improve drinking water system resilience; characterization of contamination; cleanup of contaminated wide areas including water systems; and management of contaminated waste materials. The program addresses radiological, chemical and biological threats. Dr. Sayles has conducted and managed research at the EPA for 25 years. He earned his Ph.D. in chemical engineering from North Carolina State University. He leads the research program from the EPA's laboratory in Cincinnati, Ohio.

MILITARY WATER FILTRATION

The Homeland Defense and Security Information Analysis Center received a request for research and analysis of alternative methods for water purification to support deployed troops. HDIAC provided a comparative data analysis, as well as cost-benefit analyses of water purification systems using innovative technologies in materials science, nanoparticles, graphene and hybrid techniques.

Background Information

Managing clean water systems is challenging for forward operating bases in remote and underdeveloped locations. Some FOBs lack access to potable water and raw water sources may contain chemical or biological agents that require treatment before use. [1] Water supplies in the Middle East are especially important, as troops in desert areas must drink more water in an area where the resource is scarcer. [2] Therefore, the U.S. Department of Defense spends more than $500,000 per day transporting and supplying 20,000 troops with bottled water. [1]

Enemy combatants also target supply convoys, making the logistics of importing bottled water dangerous to the warfighter. [3] During the 2007 fiscal year, the total casualties occurring during water resupply convoys numbered 15 in Afghanistan and 53 in Iraq. [4] Technologies in water filtration can meet the needs of FOBs while reducing operational costs, improving sustainability and reducing the need for water convoys. [5]

DoD Requirements

In order to adopt alternative water filtration technologies, the DoD's unique requirements must be considered. One requirement is a wholly mobile system, which is necessary for troops on the move. Current military iterations of water filtration systems, such as the Lightweight Water Purification System and Tactical Water Purification System are semi-mobile, but require a truck or Humvee for transportation. [1] Larger systems, such as the Reverse Osmosis Water Purification Unit, rely on diesel generators; [6] thereby increasing demands on additional energy resources and increasing the weight of the systems, which decreases mobility. Larger filtration systems can remove a wider variety of contaminants than their smaller counterparts, [7] which may lack the ability to remove dissolved salts, such as lead or mercury; however, these systems are immobile. [7] For the DoD, an ideal system could remove a variety of contaminants while remaining compact enough for small forces to transport. Costly operations to bring water to the troops prompts military research labs to develop alternative systems capable of filtering and desalinating water sources in the Middle East, Pacific Islands and anywhere troops are deployed. [7]

Systems

Each water filtration system's effectiveness is largely dependent on its filters. Many water purification systems fielded by the U.S. military use reverse osmosis in combination with carbon, ceramic, sand or diatomaceous earth filters. [8,9] Reverse osmosis can remove dissolved materials as small as .001 microns by filtering the water through a semipermeable membrane. [8] Additional filtration methods vary by system, but can include carbon and ion exchange filters to remove chemical and nuclear agents [8] and ultraviolet light to kill microorganisms. [10,7] Although these systems prove effective at removing contaminants, only one system, the Small Unit Water Purification System, possesses high levels of filtration while remaining mobile. The SUWPS produces up to 750 gallons of decontaminated and desalinated water daily and weighs only 80 pounds. [10] Despite its advanced capabilities, the SUWPS' intricate construction and delicate system housing makes fielding problematic. [7]

One possible solution to increasing filtration efficiency in a portable system is introducing nanoparticle filters. Carbon nanoparticles are lightweight, abundant and inexpensive. [11] Nanoparticles possess a large surface area and when combined with gold and/or silver ions are capable of destroying microbes, bacteria, viruses, mercury and other chemical contaminants. [12]
Carbon nanotubes, which allow wa-

SYSTEMS

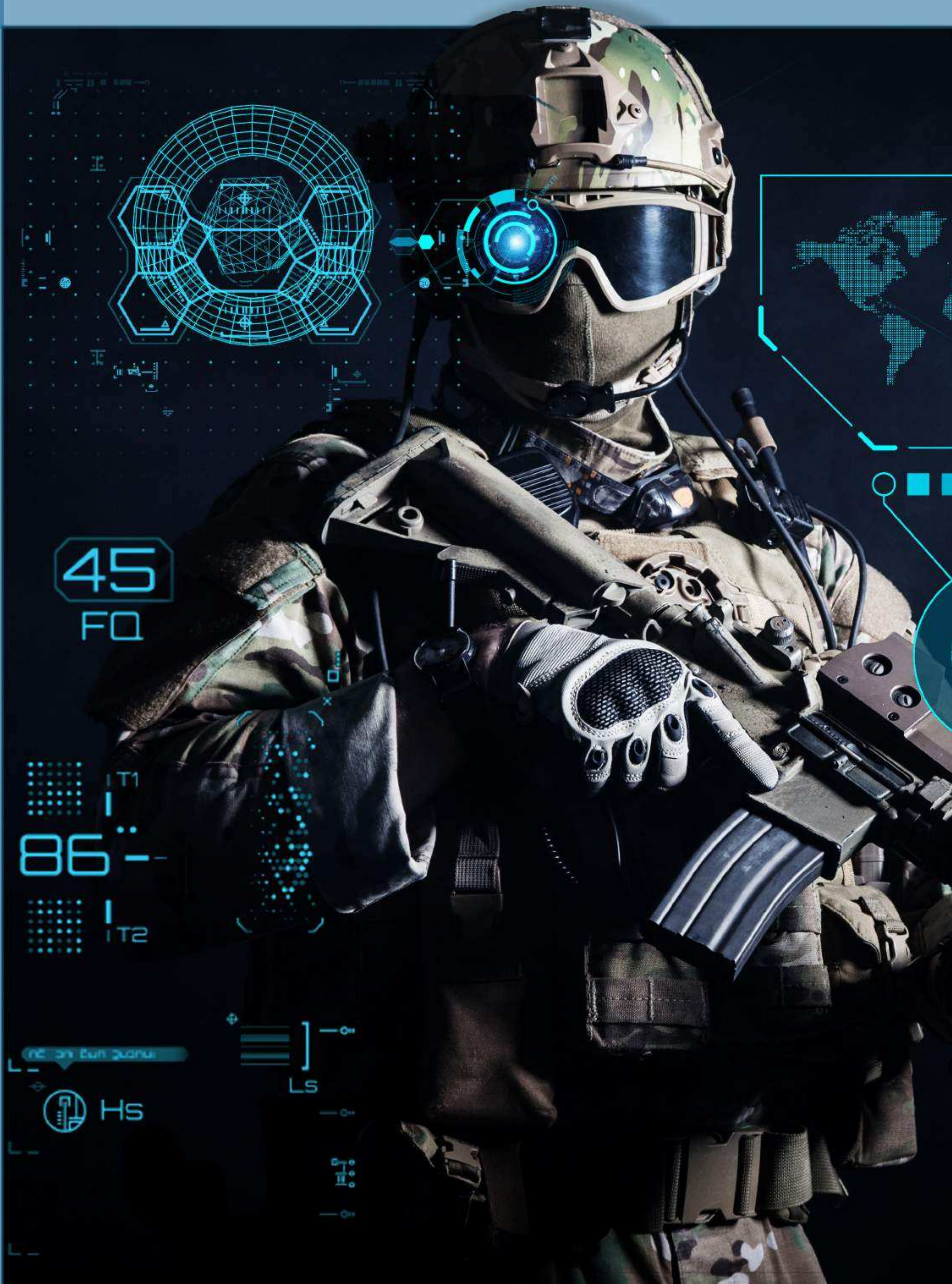
ter to pass through while rejecting most salts, ions and pollutants, are another possibility. [13] While carbon nanotubes are effective at removing heavy metals, bacteria, viruses, cyanobacterial toxins and metalloids, [12] the health risks and environmental effects of carbon nanotubes require further study before implementation in water filtration. [14] Carbon nanotubes are effective in removing a wide range of contaminants, thus their use could replace multiple filters. [12] Multi-filtration capabilities paired with affordability, availability and compact size, makes carbon nanotube filter integration a technology worth integrating into DoD water security strategic plan.

Conclusion and Recommendations

HDIAC's analysis provides the DoD an objective approach to emerging technologies in water filtration through breakthroughs in materials sciences. Current military water purification systems require improvements in mobility and filtration capabilities to meet the needs of the warfighter. Carbon nanomaterials incorporated into existing systems and developed into new water filtration systems will enable the DoD to ensure water security at FOBs and other DoD installations.

References

1. Lash, F.C. (2011). Marines Take Steps to Avoid Costly Bottled Water Resupply. National Defense Magazine. Retrieved from http://www.nationaldefensemagazine.org/archive/2011/may/pages/marinestakestepstoavoidcostlybottledwaterresupply.aspx (accessed January 12, 2016).
2. Guthrie, J. W. (2004). Obtaining and Purifying Water in Iraq. Army Logistics University. Retrieved from http://www.alu.army.mil/alog/issues/MayJun04/alog_wateriniraq.htm (accessed February 11, 2016).
3. (2009). Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys. (Rept.). Army Environmental Policy Institute. Retrieved from http://www.aepi.army.mil/docs/whatsnew/SMP_Casualty_Cost_Factors_Final1-09.pdf (accessed February 11, 2016).
4. (2009). Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys. (Rept. Pg 14). Army Environmental Policy Institute. Retrieved from http://www.aepi.army.mil/docs/whatsnew/SMP_Casualty_Cost_Factors_Final1-09.pdf (accessed February 11, 2016).
5. Treatment of Wastewater and Drinking Water. SERDP. Retrieved from https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Wastewater-and-Drinking-Water (accessed January 12, 2016).
6. Balling, F.O. (2009) Army Portable Water Treatment Units. United States Army Tank Automotive Research Development and Engineering Center (TARDEC). Retrieved from http://www.michigan.gov/documents/deq/deq-wb-wws-wss09-pres3_284554_7.pdf (accessed January 12, 2016).
7. Parsons, Dan. (2012, December). Water, Water Everywhere … That Troops Can't Drink. National Defense Magazine. Retrieved from http://www.nationaldefensemagazine.org/archive/2012/December/Pages/Water,WaterEverywhere%E2%80%A6ThatTroopsCan%E2%80%99tDrink.aspx (accessed January 12, 2016).
8. Technical Bulletin. Sanitary Control and Surveillance of Field Water Supplies. Pg. 186. Retrieved from http://armypubs.army.mil/med/DR_pubs/dr_a/pdf/tbmed577.pdf (accessed January 12, 2016).
9. Lightweight Water Purification System (LWPS). Retrieved from http://www.marcorsyscom.marines.mil/Portals/105/pdmeps/docs/WATER/B0071.pdf (accessed January 12, 2016).
10. Lab Tests Centralized Water Purification System. Army Times. Retrieved from http://archive.armytimes.com/article/20120618/NEWS/206180321/Lab-tests-centralized-water-purification-system (accessed January 12, 2016).
11. Hedman, D. et al. (2015). On the Stability and Abundance of Single Walled Carbon Nanotubes. Scientific Reports, 5: Article Number: 16850. Retrieved from: http://www.nature.com/articles/srep16850 (accessed January 12, 2016).
12. Abd El Rahman, Gepreel. (2013) Nanotechnology Applications in Water Treatment; Future Avenues and Challenges: A Review. Retrieved from http://www.researchgate.net/publication/236017947_Nanotechnology_Applications_in_Water_Treatment_Future_Avenues_and_Challenges_A_review (accessed January 12, 2016).
13. Carbon nanotube membranes for water purification: A bright future in water desalination. Retrieved from http://www.sciencedirect.com/science/article/pii/S0011916413006127 (accessed January 12, 2016).
14. Carbon nanotubes in Drinking Water Treatment. U.S. Army Public Health Command. Retrieved from http://phc.amedd.army.mil/PHC%20Resource%20Library/CarbonnanotubesApr10.pdf (accessed January 12, 2016).



SPECIAL OPERATIONS:

Leveraging Innovation to Improve Battlefield Performance

By: Jessica Hill
HDIAC BCO

INTRODUCTION

Special Operations Forces work in demanding, high-risk environments. The soldiers train to succeed in the most complex missions; they are prepared to provide expert support for national objectives; and must be capable of handling any situation from counterterrorism to civil affairs operations. [1]

Because of the extremes faced by special operators, they need to be both equipped with the best technology and creative in their responses. “In particular … creativity is the ability to rapidly change the operational method to something different from what conventional forces can use: the ability to change the game in the middle of the game.” [2]

On the home front, the United States Special Operations Command, which supports the Global Combatant Commands’ operations by providing Special Operations Forces, [3] continuously pursues the latest technological innovations to increase its effectiveness for the warfighter. By furthering developments in satellite communications and weapons systems to advancing components in the Tactical Assault Light Operator Suit, USSOCOM fosters a culture that embraces and supports innovation in research, development and acquisition programs to meet the demanding needs of the special operator.

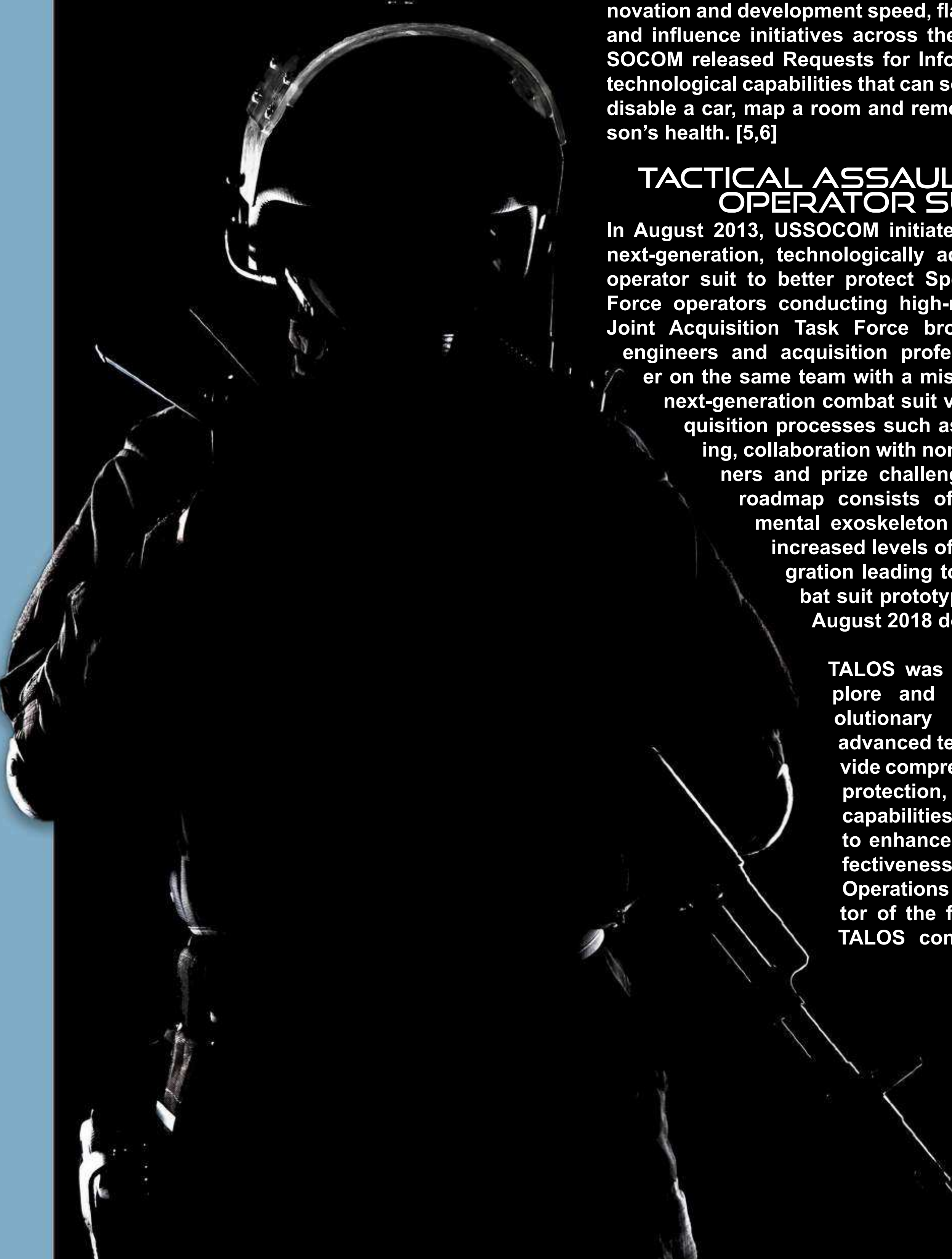
SOFWERX

Supporting the emphasis on innovation led to a partnership establishing the SOFWERX, an unclassified, open collaboration facility, designed to bring non-traditional partners from industry, academia and the government together to work on USSOCOM’s most challenging problems.

The 10,000 square foot facility serves as an incubator for innovative thinking by creating an interactive venue for “return on collisions” of untapped ideas and partnerships. The future for the SOFWERX concept includes a rapid prototyping/proof of concept facility, which is under development near the original SOFWERX facility.

The advancements conceived and developed during events and work sessions at the SOFWERX facility will benefit USSOCOM by serving to better inform future technical development, engineering decisions and provide a center for future innovation initiatives. Developing non-traditional relationships, when cemented with divergent thought and design thinking, will create a forum for innovation and accelerating technologies to USSOCOM. And, as an off-base facility, it is easier for collaborators to attend meetings, than if they took place at USSOCOM's headquarters at MacDill Air Force Base. [4]

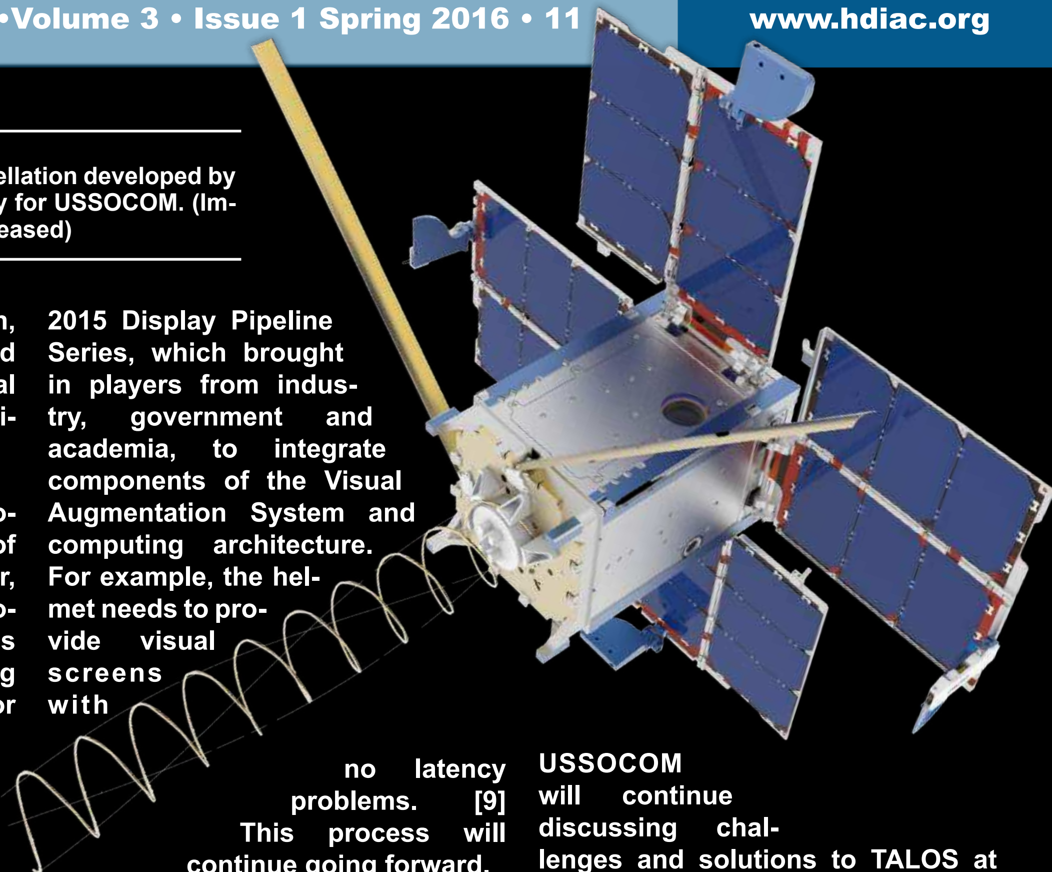
Utilizing SOFWERX will help USSOCOM overcome future challenges by continuing to attract the brightest minds and alternative approaches. These continuing relationships will allow USSOCOM to increase its innovation and development speed, flatten information and influence initiatives across the enterprise. USSOCOM released Requests for Information seeking technological capabilities that can see through walls, disable a car, map a room and remotely track a person's health. [5,6]



TACTICAL ASSAULT LIGHT OPERATOR SUIT

In August 2013, USSOCOM initiated a vision for a next-generation, technologically advanced combat operator suit to better protect Special Operations Force operators conducting high-risk missions. A Joint Acquisition Task Force brought operators, engineers and acquisition professionals together on the same team with a mission to deliver a next-generation combat suit via innovative acquisition processes such as rapid prototyping, collaboration with non-traditional partners and prize challenges. The TALOS roadmap consists of building incremental exoskeleton prototypes with increased levels of subsystem integration leading to the initial combat suit prototype scheduled for August 2018 delivery.

TALOS was chartered to explore and catalyze a revolutionary integration of advanced technology to provide comprehensive ballistic protection, peerless tactical capabilities and ultimately to enhance the strategic effectiveness of the Special Operations Forces operator of the future. When the TALOS concept was intro-



Prometheus is a CubeSat constellation developed by Los Alamos National Laboratory for USSOCOM. (Image provided by USSOCOM/Released)

duced via a Request for Information, nine aspects, including advanced armor, power generation, thermal management and embedded medical monitoring were included. [7]

Currently, armor is required to protect approximately 20 percent of the body (including head); however, TALOS anticipates full body protection. [8] This causes numerous challenges, including minimizing the weight of the armor required for whole body protection. [8]

Distinct functional areas comprise the TALOS project. Several of these functional areas utilize SOFWERX to generate innovative solutions to TALOS trials.

The primary functional areas conducting work at the SOFWERX facility are Operator Interface/Visual Augmentation Systems, for which there are test beds and workstations, as well as Survivability, for which there have been several armor design prototyping events. The OI/VAS functional area will lead the Helmet Integration effort for TALOS, some of which will take place at the SOFWERX facility. However, SOFWERX is currently only a venue to progress on components internal to the TALOS helmet.

In terms of internal helmet components, SOFWERX hosted a Fall 2015 Display Pipeline Series, which brought in players from industry, government and academia, to integrate components of the Visual Augmentation System and computing architecture. For example, the helmet needs to provide visual screens with no latency problems. [9] This process will continue going forward.

During these design efforts, Special Operations Forces operators are onsite. The constant inclusion of operator input is imperative to the success of TALOS. Operators are able to provide real time feedback and insights on engineer developments to ensure tactical relevancy.

The TALOS Power/Energy functional areas is not currently evaluating hardware at SOFWERX. Challenges for the TALOS power source include ruggedization and adapting commercial technologies to military requirements. TALOS is also monitoring industry and national laboratory efforts for potential future integration.

USSOCOM will continue discussing challenges and solutions to TALOS at the 2016 Special Operations Forces Industry Conference. Each day conference attendees will be able to offer potential solutions to challenges faced in developing TALOS. [10]

PROMETHEUS

Cube Satellites, or nanosatellites, are miniature satellites, only about four inches long and three pounds. [11] The satellites launch into space in clusters or constellations [11] for use by academia, industry and government agencies to conduct high-speed communication, data sensitive scientific exploration and educational research. [12] CubeSat technology development has been public, which encourages engi-

Article continues on page 12

SOFWERX

Article continued from page 11

neers, hobbyists and students to engage in design and capability idea development. [13] The technology also uses commercial off-the-shelf electronics, which helps mitigate costs. [14]

Prometheus is a USSOCOM CubeSat constellation developed by Los Alamos National Laboratory [15] to explore the viability of using nanosatellite constellations to meet existing Special Operations Forces mission requirements. Using the Prometheus satellites, special operators will be able to transfer audio, video and data files from man-portable, low profile, remotely located field units to deployable ground stations terminals using over-the-horizon satellite communications.

Because the Prometheus project began prior to SOFWERX, work on the technical challenges (such as minimizing the satellite's weight and reducing the number of parts) began elsewhere. [12] However, USSOCOM continues to evaluate how the Prometheus project can benefit from SOFWERX's unique environment.

One trial faced by the team developing Prometheus centered on trying to package communications electronics, antennas and sufficient power into a 1.5U (10cm x 10 cm x 15 cm) package. Working within the size constraints as well as projected development and fielding budgets is an innovation challenge. Exposing multiple developers to the Prometheus technology in the SOFWERX collaboration environment could help USSOCOM tackle the communication challenges and develop additional capabilities for the satellites.

Los Alamos National Security, in support of its USSOCOM mission, launched the eight-nanosatellite Prometheus constellation into orbit in 2013. [16] After launch, the satellites successfully communicated with controllers on the ground. [17]

Prometheus is one of a handful of initiatives geared toward improving space capability responsiveness, communications and situational awareness for the warfighter. Prometheus will assist in providing SOCOM the information needed to assess and evaluate the approach, technology, operational utility, costs and concept of operations for implementing the CubeSat system. ■

The TALOS exoskeleton is under development by USSOCOM and will better protect Special Operations Force operators in high-risk missions. (Photo by Conrad Johnson, RDECOM Public Affairs/Released)

HACKATHON

The Military Open Source Software chapter cosponsored the first Hackathon at SOFWERX and presented participants with four potential challenges:

• Open Source Intelligence Framework: Use open source software and open standards to create an infrastructure to scrape, process (including text extraction), structure and persist OSINT data.

• Ensuring Cloud Security of Server Instances: Using a public cloud provider (e.g., Amazon, Microsoft, Google, Rackspace, etc.) install and configure a standard Windows 12 and/or Linux system. Automate (to the degree feasible) the actions to check and configure the server(s) to ensure they are installed and operating securely to protect the confidentiality, integrity and availability of data. Provide a checklist for procedures that cannot be easily automated.

• Common Operating Model: Starting with TacMap as the software base, demonstrate how using 3D models of urban terrain can support real-time visualization of the location and status of unit element (including drones). Feel free to add any other useful HUD-oriented data that might be useful for tactical urban operations.

• 3D Model Visualization and Collaboration: Use existing open source software frameworks to build a 3D multi-modal collaboration

REFERENCES

1. 2015 USSOCOM Posture Statement: Hearings before the House Armed Services Committee Subcommittee on Emerging Threats and Capabilities. (2015, March 18). (Statement of General Joseph L. Votel, U.S. Army Commander, United States Special Operations Command). Retrieved from http://www.socom.mil/Documents/2015%20USSOCOM%20Posture%20Statement.pdf (accessed February 11, 2016).
2. Spaluk, Robert G. (2010, December). Innovate or Die: Innovation and Technology for Special Operations. Joint Special Operations University. Retrieved from http://jsou.socom.mil/JSOU%20Publications/JSOU10-7spulakInnovate_final.pdf (accessed February 11, 2016).
3. United States Special Operations Command (USSOCOM). Retrieved from http://www.socom.mil/default.aspx (accessed February 11, 2016).
4. Altman, Howard. (2015, November 4). SOCOM's 'hackathon' opens process of creating high-tech commando gear. The Tampa Tribune. Retrieved from http://www.tbo.com/list/military-news/hackathon-opens-process-of-creating-hi-tech-commando-gear-20151104/ (accessed February 11, 2016).
5. TE 15-3 Technical Experimentation Urban/Unconventional Warfare (2015, March 2). FedBizOpps.gov. Retrieved from https://www.fbo.gov/index?s=opportunity&mode=form&id=855bf3ada22f7e5a7061eedceafdc739&tab=core&_cview=0 (accessed February 11, 2016).
6. Kamm, Grayson. (2015, March 30). SOCOM wants real video games and superhero tech. 10News. Retrieved from http://www.wtsp.com/story/tech/2015/03/30/socom-wants-real-video-game-and-superhero-tech/70658262/ (accessed February 11, 2016).
7. Hoarn, Steven. (2013, May 18). SOCOM seeks TALOS (Tactical Assault Light Operator Suit). Defense Media Network. Retrieved from http://www.defensemedianetwork.com/stories/socom-seeks-talos-tactical-assault-light-operator-suit/ (accessed February 11, 2016).
8. Vergun, David. (2015, January 28). Unprecedented technology poses challenges for special ops. United States Army. Retrieved from http://www.army.mil/article/141816/Unprecedented_technology_poses_challenges_for_special_ops/ (accessed February 11, 2016).
9. Magnuson, Stew. (2015, May). Power Remains Key Challenge for Building SOCOM's Iron Man Suit. National Defense Magazine. Retrieved from http://www.nationaldefensemagazine.org/archive/2015/may/pages/powerremainskeychallengeforbuildingsocomsironmansuit.aspx (accessed February 11, 2016).
10. Special Operations Forces Industry Convention Agenda. Retrieved from http://www.sofic.org/agenda/Documents/Agenda_2-5-16.pdf (accessed February 11, 2016).
11. CubeSats Overview. NASA website. Retrieved from http://www.nasa.gov/mission_pages/cubesats/overview (accessed February 11, 2016).
12. CubeSat to Demonstrate Miniature Laser Communications in Orbit. (2015, October 9). NASA Press Release. Retrieved from http://www.nasa.gov/press-release/cubesat-to-demonstrate-miniature-laser-communications-in-orbit (accessed February 11, 2016).
13. Cabalier, D. and Pang, A. (2009). The Growth of Citizen Science: How Amateurs are contributing to Research. The New York Academy of Sciences. Retrieved from http://www.nyas.org/Publications/Detail.aspx?cid=5222b62e-4a1b-4fb2-bf6e-a38e263dee49 (accessed February 11, 2016).
14. Space Systems Laboratory. About CubeSat. Retrieved from http://ssl.engineering.uky.edu/missions/orbital/about-cubesat/ (accessed February 11, 2016).
15. Mattox, E. (2014). Special Operations Takes Flight to the High Ground. The Space Review. Retrieved from http://www.thespacereview.com/article/2491/1 (accessed February 11, 2016).
16. Innovative Micro & Small Space Vehicles (SV). (2014, August 4). Los Alamos National Laboratory. Retrieved from https://www.lanl.gov/projects/feynman-center/_assets/pdf/RFI-ASP-8-1-14.pdf (accessed February 11, 2016).
17. Tripp, Justin Leonard. (2015, July). Satellites and System Design. Retrieved from http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-15-25952 (accessed February 11, 2016).

environment. The environment should allow the ability to input models into a model database, search, organize and view models and collaborate with others on the model whereby "control" of the model can be passed between participants (like the "presenter" status in a web conference) so that the "presenter" can bring models together, change orientation, etc. to visually demonstrate model requirements to viewers.

For this challenge, the winning Hackathon team (Team Shudder) created a novel heads up display that integrated data from satellite feeds to show what was behind walls or buildings or was otherwise obstructed from the operator's view. Their concept and design was so novel USSOCOM invited the team back to participate in a heads up display technology sprint for TALOS. This is an example of the unique input and non-traditional performer USSOCOM is attempting to attract using open collaboration and SOFWERX.

The next Hackathon is planned for May 20-22, 2016 – the weekend before USSOCOM's Special Operations Forces Industry Conference and International Special Operations Forces week. It will include partnerships with Air Force Research Lab and organizations from the intelligence community, and feature challenges in the international collaboration and partnering space. In addition, USSOCOM added monthly "mini-hacks" to allow Hackathon participants to continue working together on USSOCOM problems, and build further on the relationships formed during the other events.

Unfamiliar Face Recognition

By: David J. Robertson, Ph.D.
& Mike Burton, Ph.D.

Security, Surveillance and Smartphones

Familiar Face Recognition

A person's ability to recognize familiar faces across a wide range of viewing conditions is one of the most impressive facets of human cognition. As shown in Figure 1, it is easy to conclude, for a known individual, that each image in the set shows the same person (British Prime Minister David Cameron), despite a wide range of variation in viewing angle, physical appearance, camera and lighting. In fact, familiar face recognition performance is often at or near ceiling level, even when the images are of poor quality [1] or artificially distorted. [2] At first glance, the aptitude for familiar face recognition may suggest a similar level of expertise for the recognition of unfamiliar faces, thus the reliance on face-to-photo ID for identity verification. [3] This is not the case, as recent research shows people are surprisingly poor at recognizing new instances of an unfamiliar person.

Figure 1. Ambient photos of the same face (U.K. Prime Minister David Cameron). All images used under Creative Commons or Open Government License. (Released)

The poor recognition of unfamiliar faces is a concern for the United States. Many preliminary screenings involve facial recognition by security agents. In order for this method to be effective, more robust training for security agents needs to be established. The Department of Defense utilizes facial and iris recognition technologies in order to eliminate human error in identifying persons of interest during surveillance operations. [4] DoD guidelines should be implemented by security agent guidance programs to ensure best practices in identification of potential threats.

Unfamiliar Face Recognition: Studies on the General Population

The Glasgow Face Matching Test [5] is a well-established measure of unfamiliar face recognition performance. As illustrated in Figure 2, this simple psychometric test requires participants to decide whether pairs of unfamiliar faces show two instances of the same person (taken seconds apart using different cameras) or two different people. The GFMT captures the real life 1-1 matching situations encountered on a daily basis by passport control officers (i.e. matching a face to a passport photo) and military personnel (i.e. matching a face image captured from surveillance footage to images held on file). In the GFMT, viewers are not required to remember anything and can take as long as they like to make their decisions.

As seen in Figure 2, the GFMT trials use high quality front-facing images. Despite this, accuracy on this task is generally poor with error rates between 15 and 20 percent being the norm across hundreds of participants tested. Even the lower end of the estimate, 15 percent, is a non-trivial level of error in many circumstances. For example, millions of international passengers pass through airports each day. If this error rate were similar in professional groups (see next section) it would be unacceptably high.

Another striking example of poor performance in a test of unfamiliar face recognition was modeled on an old-fashioned police line-up scenario involving a series of one-to-ten unfamiliar face matching arrays. [6] The task was intended to emulate the best-case scenario for identifying images captured on a security video. As seen in Figure 3(a), participants were presented with a single high quality image of a 'suspect' taken from video footage and an array of 10 face images. Participants decided whether the suspect was present in the array, and if present, attempted to pick out the correct image. Despite using high quality images and video stills taken on the same day, in a similar pose and in optimal lighting conditions, error rates on this task were unacceptably high, at 30 percent on average. Performance dropped further with lower quality surveillance video. [7]

Researchers replicated this level of error using the same task and extended the findings to include the effects of race or ethnicity. [8] Using the same

Figure 2. An example of two trials from the Glasgow Face Matching Test. The top pair shows two instances of the same person (match trial), the bottom pair shows two different people (mismatch trial). (Released)

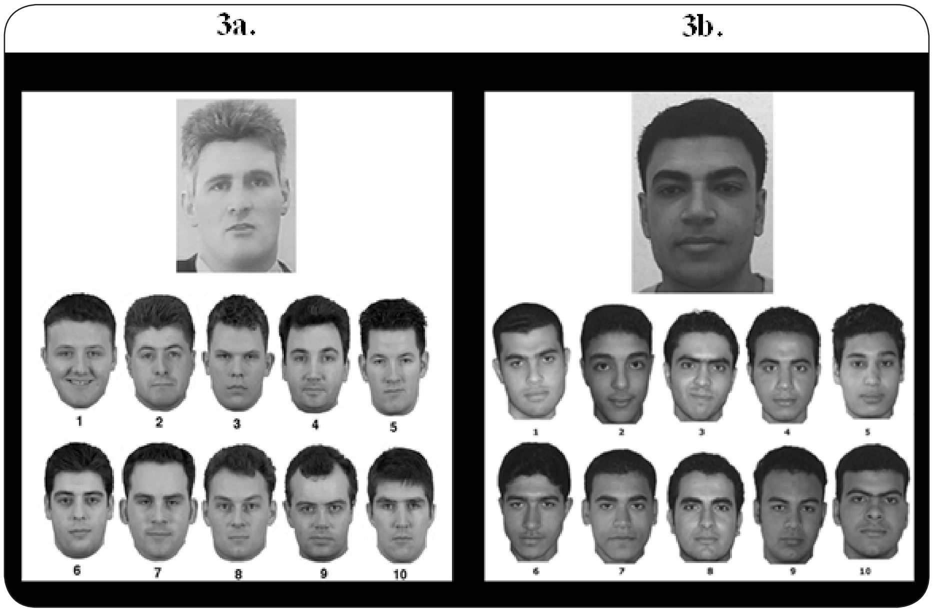


Figure 3(a). An example of a one-to-ten matching trial from Reference 6. In this example, the suspect pictured above the array is not present in the line-up below. Figure 3(b). An example of a one-to-ten matching trial from Reference 8. In this example, the suspect is present in the array, at position number 10. (Released)

matching task, [6] the researchers asked U.K. and Egyptian participants to complete the one-to-ten task using faces of people from the U.K. and from Egypt. [8] When participants performed the recognition test with faces from their own ethnic group (e.g., U.K. participant using U.K. face arrays), error rates were in line with those in earlier studies. [6,8] However, when participants were required to match faces from an opposite ethnic background, (e.g., U.K. participant using Egyptian face arrays; see Figure 3b) error rates rose to 40 percent. This is known as the 'other race effect' and is of particular importance considering a proportion of people attempting passport fraud or under military surveillance are likely to be unfamiliar other race individuals. Hence, accurate recognition of unfamiliar individuals for the purposes of detecting passport ID fraud or for military surveillance may be more difficult when the person is a foreign national.

The above studies provide insight into laboratory tests of unfamiliar face recognition. One criticism of these findings is that they focus on matching face photographs, whereas in the real world accurate matching involves real faces. Research shows, however, that matching a face photo to the face of a live person is just as difficult and error-prone as matching face images. For example, one study reported an error rate of 17 percent when participants were asked to match recent photos to live faces. [9] A later study reported more than 30 percent of participants made identification errors when asked to match recent high quality closed-circuit television images to a live defendant in a courtroom scenario study. [10] Unfamiliar face recognition is just as bad in real life as it is when matching two photos.

Unfamiliar Face Recognition: Studies on Specialists

The laboratory-based studies described above provide important insights into the accuracy of unfamiliar face recognition. However, these studies were performed using non-specialist viewers from the general population. While study results are informative, it is important to know whether people who carry out these tasks professionally are able to perform more accurately than untrained viewers.

A seminal study tested whether the inclusion of a face photo on credit cards would reduce fraud. [11] The study used real supermarket cashiers who routinely check photo-ID cards to prevent the sale of age-restricted goods, such as cigarettes and alcohol. Remarkably, it was reported that the retail staff accepted fraudulent photo credit cards (i.e. the photo did not depict the bearer) as genuine in 50 percent of trials. It is striking that this performance could be so poor, given that matching

Figure 4. Examples of the images used in Reference 1: A still from a CCTV video (left) and a high quality face photo (right). (Released)

faces to photo-ID cards is an important part of the job. While it could be argued that retail stores do not have the resources to provide training in photo-ID verification, this is not a criticism that can be leveled at studies involving police officers or passport officials, described next.

U.K. Police Officers

Researchers tested whether a group of U.K. police officers, with experience in forensic identification, would perform better than a group of untrained university students on a test of unfamiliar face recognition. [1] As seen in Figure 4, participants were required to view low quality video clips of individuals entering a building. They were told that they would later be asked to identify these people. The participants looked at high quality face photos and were asked to rate how confident they were that these individuals had been present in the video clips.

The results of the study showed that the police officers performed very poorly on this task, and in fact, did no better than the group of students. Hence, any training the officers had in forensic identification appeared to provide no assistance when it came to recognizing new instances of an unfamiliar face.

Australian Passport Officials

A recent major study of unfamiliar face recognition in Australian passport officers, conducted in collaboration with the Australian Department of Foreign Affairs, asked 30 passport officers to decide whether a passport photo matched the face of a person standing in front of them. [12] The study found passport officials incorrectly accepted a fake passport photo as genuine in 14 percent of trials. Interestingly, the findings also showed no relationship between employment duration/experience and accuracy on this task, as illustrated in Figure 5. That is, those who had 20 years' experience at the passport office were no more likely to be accurate than those who had just started working with the service.

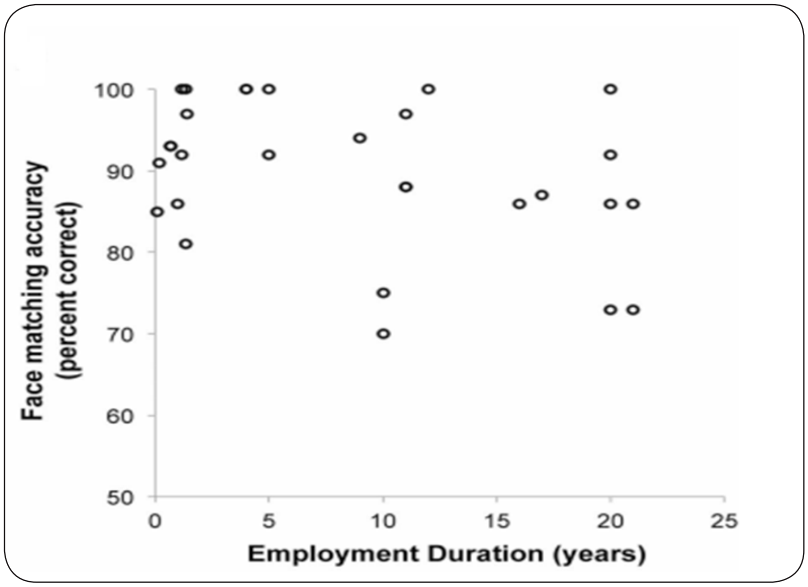


Figure 5. Unfamiliar face recognition accuracy (live face-passport photo) for Australian passport office staff presented as a function of employment duration. [12] (Released)

As the figure shows, there were very large individual differences between officers. In fact, this is the standard finding—some people consistently perform better at face tasks than others. Once again, the important point here is, in another specialist group, professional training and experience does not appear to lead to more accurate unfamiliar face recognition.

While the incidence of attempted passport fraud is very low, researchers recently showed that this, in itself, leads to an additional source of error. [13] In a phenomenon known as the low prevalence effect, researchers found that detecting unfamiliar mismatch face pairs was much poorer when they occurred on 10 percent of trials in comparison to 50 percent of trials. These findings suggest that a lack of familiarity with travelers and the low incidence of attempted passport fraud present major security risks at border control points.

How Can We Improve Unfamiliar Face Recognition Performance?

Based on the experimental evidence outlined above, it is clear that unfamiliar face recognition is a difficult task which is highly prone to error. This is the case regardless of whether the task involves photos or real faces, and whether it involves professional or untrained viewers. For the foreseeable future, reliance on face recognition for ID verification will continue at many border control points and in military operations. Consequently, recent research focused on ways to improve human performance in this domain.

Selection

As seen in Figure 5, researchers showed that recognition performance did not relate to occupational experience or years in employment; some individuals were simply better than others at this task. [12] This finding suggests that using an established test, such as the GFMT, [5] could help select high performing people for jobs in which accurate unfamiliar face recognition is a critical component of the job.

Paired Decision Making

Research shows that performance on recognition tests can be improved when participants work together and come to a judgment in pairs. [14] Across four experiments, the study tested unfamiliar face recognition individually (pre-test), as pairs (paired-test) and again individually (post-tests). The authors report that participants were more accurate when they made their judgments in pairs than individually. Furthermore, those who started with low performance showed a lasting benefit of having worked in pairs, suggesting that this type of procedure may be a particularly effective training method.

Multi-Photo ID

A different approach to improving unfamiliar face matching focuses on the ID document itself. The selection of photos for passports is a complex process,

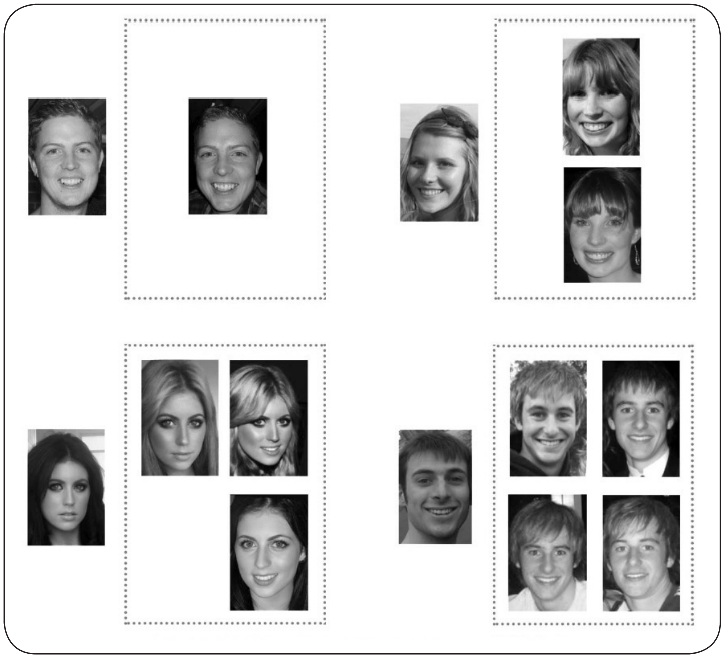


Figure 6. An example of the face matching arrays from reference 12. A single face is presented to the left, the array of photos to the right. Participants decide if the face on the left matches the photo(s) on the right. The example arrays showing one and three photos show the same person (match trials), while arrays showing 2 and 4 photos show different people (mismatch trials). (Released)

and one that differs between countries. Despite rather strict rules about the format required for these photos, people often comment that their IDs look rather unlike them. What modern research makes clear is that a single instance of a person can never form a true representation of their appearance. One suggestion is that the key to improving unfamiliar face recognition is learning how an individual varies across a naturally occurring set of instances. In other words, familiarity is shorthand for learning an individual's idiosyncratic variation in appearance. [15] It would be possible to achieve this for photo-ID by increasing the number of photos required on an ID document. Researchers reported that unfamiliar face matching performance significantly improved when mock ID cards contained two, three or four photo arrays (see Figure 6). [16] So, a relatively small increase in the number of photos contained on an ID card could reduce the error found with single image identity documents.

Automatic Face Recognition

Due to recent technological advances, there has been an increase in the use of automatic face recognition systems at airports, in military surveillance operations and even in social media (e.g., Facebook). Using the example of implementing electronic facial recognition gates (e-gates) at airports across the world, the expectation is these machines would remove the level of human error reported in the above passport officers' study. However, there is evidence to suggest that machine recognition systems are not providing the level of performance claimed by the developers. [17] Indeed, a recent report by the U.K. Inspectorate of Borders questioned the level of security provided by the e-gates.

The report cited an example in which a married couple was able to accidentally swap their passports and still make it through the e-gate system. Despite these systems performing well in benchmark tests, they routinely perform poorly in real world settings. [18] In the next section, we outline research which shows that current machine recognition performance can improve without any alterations to the algorithm.

Improving Automatic Face Recognition

No machine recognition system currently emulates the level of recognition accuracy found in humans when dealing with familiar faces. As noted above, familiar viewers are able to recognize photos of someone they know despite changes in lighting, camera characteristics, pose, expression and age. Unfamiliar face recognition in humans and machines is thought to be so poor precisely because these systems do not have

Figure 7. Individual images of the same person can look very different. Averaging these together produces a stable image, which will match a much wider range of the user's face and improve security. (Released)

Figure 9. Images of the six different locations used in Reference 27 to test the effectiveness of face averages. (Released)

access to ways in which an individual's appearance varies. Previous research suggests the brain may become familiar with a person by storing many different instances of them in memory. [19] However, in contrast, another study proposed that people may store an abstract representation of a person's face which retains identity specific information and discards irrelevant information which varies across images (e.g., lighting etc.). [20] This abstract representation, essentially a morph of different images, is called a face average and an example can be seen in Figure 7.

In an effort to track travel of non-U.S. citizens to the United States, the U.S. Customs and Border Protection uses biometric technology at the border to capture face and iris scans of all individuals entering or exiting the country. [21] Non-U.S. citizens traveling to the United States also require a visa that implements biometric identifiers, such as fingerprint scans, as well as a digital photo, unless they are part of the Visa Waiver Program. [22] This will allow the CBP to utilize a database instead of facial recognition, which is prone to human error. Facial recognition alone has proven to be an unreliable source and with the new data the CBP is collecting, it will be able to track persons of interest and foreign travel to ensure safety. [23]

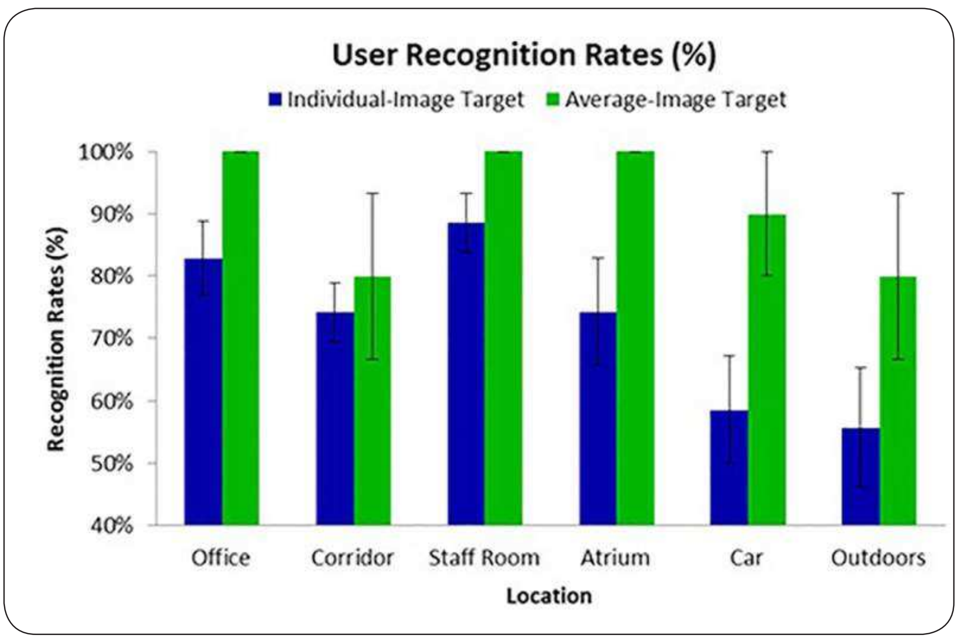


Figure 8. Shows the mean automatic face recognition accuracy when storing a person's face average (green) compared to an individual image of them (blue). Performance is shown for each of the six testing locations. (Released)

To protect sensitive information, as well as the homeland, federal agencies issue identification cards containing biometric data to federal employees and contractors. [24,25] This process makes it more difficult for unauthorized individuals to access secure facilities. Additionally, the use of stolen or counterfeited badges no longer poses a threat without the matching biometrics of the personnel. A multimodal method of detection is the most robust.

Research showed that face averages could be used to improve an automatic face recognition system. [20] This study assessed the performance of an online version of the then industry standard recognition system, FaceVACS. This system contained a large database of celebrity face photographs, (more than 30,000 images and more than 3,000 celebrities) which varied considerably in illumination, pose, facial expression, age and image quality. Users would upload a photo and the system would return the closest matching image in its database.

When the researchers uploaded individual images of different celebrities, they found the system would only return another picture of the correct identity on 54 percent of occasions [26] – a rather poor level of performance. However, when celebrities' face averages were uploaded, the system achieved perfect levels of performance (100 percent accuracy). This provided clear evidence that using a person's face average, rather than an instance of them, could dramatically improve machine recognition without an alteration to the algorithm.

While some research established the face average advantage using photo-to-photo matching, [26] a more recent study assessed whether the advantage remained when dealing with the recognition of real faces. [27] This study used the 'face-unlock' security system in the Samsung Galaxy smartphone. This system allows users to store an image of their face in the phone's memory, which can be used to recognize the user and allow access as an alternative to passcodes. Researchers reported that when they stored a person's face average rather than an instance of them, real face recognition rates were significantly increased, sometimes to perfect levels of performance as seen in Figure 8. [27] Impressively, this effect held across a variety of everyday environmental conditions, including outdoors, as seen in Figure 9.

In summary, face averages have been shown to improve machine recognition performance both with face photos and real faces. This technique could be particularly important to police or military operations, which are required to match a suspect or surveillance target to face photos held on a large database. Additionally, if face averages replaced individual photos on passports, e-gate security systems may perform better than they currently do.

Conclusions

This article presents experimental evidence, which shows that unfamiliar face recognition is a difficult task and one that is highly prone to error. Despite this, reliance on face photos for identity verification in domains with direct implications for national security continues. Research has identified several ways of improving human and machine face recognition. Other forms of biometric security, such as the iris scan, have the potential to replace face photo-ID in the future. However, many agencies around the world prefer to use faces for identification, possibly because their use is relatively unobtrusive, and appears natural. This article shows the limitations of this reliance.

The difficulty in recognizing unfamiliar faces is a security concern for the United States and requires increased use of biometric data for more accurate identification. This is especially critical when identifying individuals privy to sensitive information, non-citizens entering or leaving the United States, as well as criminals or terrorists. Incorrect identification of these individuals leaves the United States vulnerable.

The DoD fields an Automated Biometric Identification System to house and share biometric data. Originally developed for Operation Iraqi Freedom and Operation Enduring Freedom, ABIS is used to identify persons of interest that have a prior criminal history and are deemed as potential threats to U.S. forces. [28] In order to enable intelligence sharing amongst federal agencies, information within this system is shared with interagency partners like the Federal Bureau of Investigation and external partners that include the CBP and U.S. Citizenship and Immigration Services.

References

1. Burton, A., Wilson, S., Cowan, M., & Bruce, V. (1999). Face Recognition in Poor-Quality Video: Evidence From Security Surveillance. *Psychological Science*, 10, 243-248. doi: 10.1111/1467-9280.00144
2. Hole, G., George, P., Eaves, K., & Rasek, A. (n.d.). Effects of geometric distortions on face-recognition performance. *Perception*, 31, 1221-1240. doi: 10.1068/p3252
3. Ritchie, K., Smith, F., Jenkins, R., Bindemann, M., White, D., & Burton, A. (2015). Viewers base estimates of face matching accuracy on their own familiarity: Explaining the photo-ID paradox. *Cognition*, 141, 161-169. doi: 10.1016/j.cognition.2015.05.002
4. Face Recognition. (2006, Aug. 7) Biometrics.gov. Retrieved from http://

www.biometrics.gov/Documents/face-rec.pdf (accessed January 12, 2016).

5. Burton, A. M., White, D., and McNeill, A. (2010). The Glasgow Face Matching Test. *Behavior Research Methods*, 42(1) 286 - 291. Retrieved from http://homepages.abdn.ac.uk/m.burton/pages/BWM2010.pdf (accessed January 12, 2016).
6. Bruce, V., Henderson, Z., Greenwood, K., Hancock, P., Burton, A., & Miller, P. (1999). Verification of face identities from images captured on video. J*ournal of Experimental Psychology: Applied*, 5(4), 339-360. doi: 10.1037/1076-898X.5.4.339
7. Henderson, Z., Bruce, V., and Burton, A. M. (2001). Matching the faces of robbers captured on video. *Applied Cognitive Psychology*, 15(4), 445-464. doi: 10.1002/acp.718
8. Megreya, A. M., White, D., and Burton, A. M. (2011). The other-race effect does not rely on memory: Evidence from a matching task. *The Quarterly Journal of Experimental Psychology*, 64(8), 1473-1483. doi: 10.1080/17470218.2011.575228
9. Megreya, A. M., and Burton, A .M. (2008). Matching faces to photographs: Poor performance in eyewitness memory (without the memory). *Journal of Experimental Psychology: Applied*, 14, 364-372. doi: 10.1037/a0013464
10. Davis, J. P., and Valentine, T. (2009). CCTV on trial: Matching video images with the defendant in the dock. *Applied Cognitive Psychology*, 23(4), 482-505. doi: 10.1002/acp.1490
11. Kemp, R. I., Towell, N., and Pike, G. (1997). When seeing should not be believing: Photographs, credit cards and fraud. *Applied Cognitive Psychology,* 11(3). 211–222. doi: 10.1002/(SICI)1099-0720(199706)11:33.3.CO;2-F
12. White, D., Kemp, R.I., Jenkins, R., Matheson, M., and Burton, A.M. (2014). Passport Officers' Errors in Face Matching. *PLoS One*, 9(8). doi: 10.1371/journal.pone.0103510
13. Papesh, M. H., and Goldinger, S. D. (2014). Infrequent identity mismatches are frequently undetected. *Attention, Perception and Psychophysic*s, 76(5), 1335–1349. doi: 10.3758/s13414-014-0630-6
14. Dowsett, A. J., and Burton, A. M. (2015). Unfamiliar face matching: Pairs out-perform individuals and provide a route to training. *British Journal of Psychology*, 106(3), 433-445. Retrieved from http://eprints.whiterose.ac.uk/85532/1/Pairs_Paper_inpress.pdf (accessed January 12, 2016).
15. Burton, A. M. (2013). Why has research in face recognition progressed so slowly? The importance of variability. *Quarterly Journal of Experimental Psychology*, 66(8), 1467-1485. doi: 10.1080/17470218.2013.800125
16. White, D., Burton, A.M., Jenkins, R., and Kemp, R. (2014). Redesigning photo-ID to improve unfamiliar face matching performance. *Journal of Experimental Psychology: Applied*, 20, 166-173. doi: 10.1037/xap0000009
17. Jenkins, R., and Burton, A. M. (2011). Stable face representations. *Philosophical Transactions of the Royal Society of London*, B, 366(1571), 1671-1683. doi: 10.1098/rstb.2010.0379
18. Jenkins, R., and White, D. (2009). Commercial face recognition doesn't work. *Bioinspired Learning and Intelligent Systems for Security*, 2009. BLISS'09. Symposium on, 43-48. IEEE. doi: 10.1109/BLISS.2009.22.
19. Longmore, C. A., Liu, C. H., and Young, A. W. (2008). Learning faces from photographs. *Journal of Experimental Psychology: Human Perception and Performance*, 34(1), 77–100. doi: 10.1037/0096-1523.34.1.77
20. Burton, A. M., Jenkins, R., Hancock, P. J., and White, D. (2005). Robust representations for face recognition: The power of averages. *Cognitive Psychology*, 51, 256–284. doi: 10.1016/j.cogpsych.2005.06.003
21. CBP to Begin Biometric Entry/Exit Testing at Otay Mesa Port of Entry. (2015, December 10). Retrieved from https://www.cbp.gov/newsroom/local-media-release/2015-12-10-000000/cbp-begin-biometric-entryexit-testing-otay-mesa-port (accessed January 12, 2016).
22. Safety and Security of U.S. Borders: Biometrics. (2015) U.S. Department of State. Retrieved from https://travel.state.gov/content/visas/en/general/border-biometrics.html (accessed January 12, 2016).
23. CBP to Begin Biometric Entry/Exit Testing at Otay Mesa Port of Entry. (2015, December 10). Retrieved from https://www.cbp.gov/newsroom/local-media-release/2015-12-10-000000/cbp-begin-biometric-entryexit-testing-otay-mesa-port (accessed January 12, 2016).
24. Biometrics Frequently Asked Questions. (2006). National Science and Technology Council's Subcommittee on Biometrics. Retrieved from http://biometrics.gov/Documents/FAQ.pdf (accessed January 12, 2016).
25. Personal Identity Verification (PIV) Credential. (2015). U.S. General Services Administration. Retrieved from http://fedidcard.gov/ (accessed January 12, 2016).
26. Jenkins, R., and Burton, A.M. (2008). 100% accuracy in automatic face recognition. *Science*, 319(5862), 435. doi: 10.1126/science.1149656
27. Robertson, D. J., Kramer, R. S. S., and Burton, A. M. (2015). Face averages enhance user recognition for smartphone security. *PLoS One*, 10(3). doi: 10.1371/journal.pone.0119460
28. DoD Automated Biometric Identification System (ABIS). (2013). Army Programs. Retrieved from http://www.dote.osd.mil/pub/reports/FY2013/pdf/army/2013dodabis.pdf (accessed January 12, 2016).

David J. Robertson, Ph.D., is a post-doctoral research scientist in Mike Burton's face research group. His work focuses on assessing and improving unfamiliar face recognition in professional contexts (see www.facevar.com).

Mike Burton, Ph.D., is a professor of Psychology and a specialist in face recognition research. His current work, supported by major grants from the ERC and ESRC, is focused on improving our understanding of face recognition in both theoretical and applied contexts.

Safety Culture in the U.S. Pipeline Industry

The Homeland Defense and Security Information Analysis Center received a request for research and analysis of safety culture assessments and incident rates within the U.S. pipeline industry. HDIAC highlighted the most commonly occurring safety incidents in the pipeline industry over the last 10 years and provided possible solutions for reducing occurrences of multiple types of safety incidents. In addition, HDIAC compiled tables to display the most common incident types alongside their total property damage costs by year. Also provided in the inquiry were tables showcasing companies with the most safety violations over the last 10 years, measured by the total number of corrective action orders received and a list of pipeline companies that carried out safety culture assessments.

Background

In 2013, the United States contained 1.7 million miles of oil and gas pipeline. [1] The vast network of oil and gas pipelines makes incident prevention difficult as shown by the recent increase in reported safety incidents for 2015. [2] Prevention becomes more challenging due to the varied types of safety concerns and incidents. Equipment failures, corrosion, incorrect operation, excavation and natural and outside forces are the most costly and commonly occurring safety concerns for the pipelines. [2]

Safety incidents can result in injury or loss of life, as well as significant property damage. [2] The Pipeline and Hazardous Materials Safety Administration promotes safer operating procedures through the use of enforcement actions to reduce the occurrence of safety incidents. Corrective action orders, the strongest enforcement action issued by the PHMSA, focus on “urgent situations arising out of an accident, spill, or other significant, immediate, or imminent safety or environmental concern.” [3] From 2005-2014, PHMSA issued 77 corrective action orders, [4] with an average of 1.79 corrective action orders by company. [4]

Infrastructure Weakness and Damage

More than 100,000 miles of pipelines built during or prior to the 1930s still exist in the United States. [5] These dated lines were constructed with leak-prone materials, such as cast iron, bare steel and unprotected coated steel, [5,6] making pipeline failure and corrosion the two most common types of safety incidents reported by PHMSA. [2] Replacing aged infrastructure will reduce safety incidents caused by failure and corrosion.

Damage also occurs from natural forces, such as floods, landslides and high winds, as well as damage from outside forces including vehicle impact, vandalism and terrorism. [7,8] Hurricanes, earthquakes and other weather-related events are difficult to protect against. [8] Outside forces primarily impact aboveground infrastructure in densely populated areas. [7] Placing pipeline infrastructure below ground reduces the risks of damage by outside forces and may assist in protecting against some natural forces.

Although burying all possible infrastructure underground may lower the number of incidents caused by both natural and outside forces, underground pipelines are still susceptible to damage caused by excavation events, including digging, trenching and grading. [9] To reduce the risk of excavation related incidents, pipeline location and depth must be more accurately marked.

Incorrect Operation

Incorrect operation incidents resulting from human error are one of the least common incident types in the pipeline industry. [10,2] Increased autonomy of pipeline infrastructure, while encouraging further safety training among necessary personnel, may reduce these incidents. Other possible ways of reducing safety incidents, especially those involving human error, is the inclusion of safety culture assessments. By increasing safety awareness, employees are less likely to engage in behavior that may cause a safety incident, such as overfilling a tank, over pressurizing equipment, using improper equipment or techniques and not following established procedures. [10]

Cyberattacks

Due to a rise in cyberattacks on critical infrastructure, [11] HDIAC's analysis also included cyber threats. Although there was no PHMSA data on cyber related incidents, cyber threats are a growing concern to pipeline infrastructure. Many vulnerabilities arise with the connection of Supervisory Control and Data Acquisition systems to the Internet. [12,13] Weak, default or non-existent login credentials required to access the systems further compound this problem. [13] To mitigate the risks of a cyber intrusion capable of hijacking control systems, HDIAC proposed stronger password requirements and limiting access to necessary on-site personnel.

Recommendations and Conclusion

HDIAC's analysis determined certain types of safety incidents, such as corrosion and equipment failure, would become less prevalent by replacing aging pipeline infrastructure. Continuous efforts to reduce safety incidents include employee training and/or simulations, burying available infrastructure underground and increasing the use of safety culture assessments. As other types of safety incidents become less common, research shows that cyber threats against pipeline infrastructure would become more prevalent. [14]

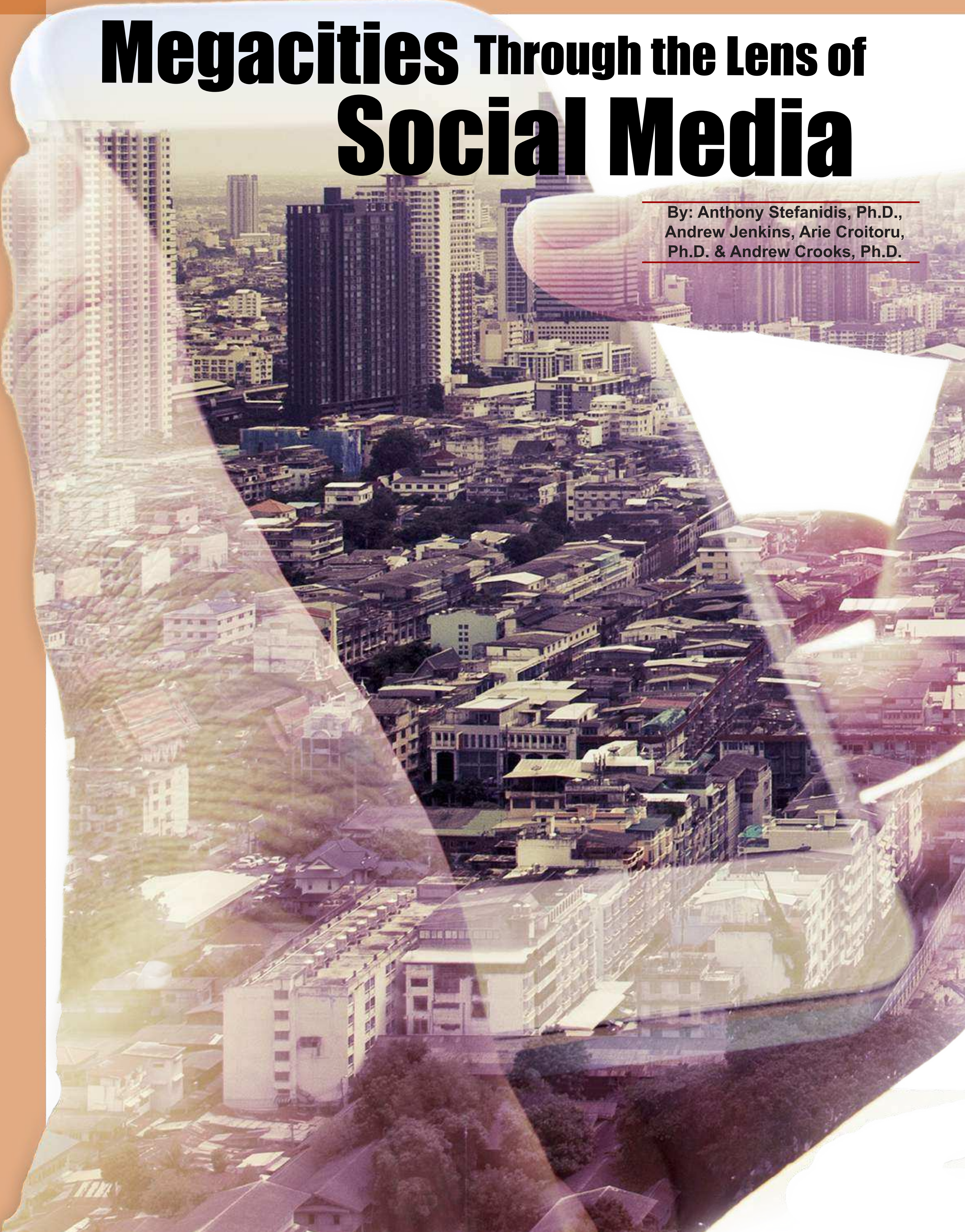
The information provided by HDIAC allows the customer to view the trend of pipeline incident types over the last 10 years and prepare mitigation efforts to reduce their occurrence and overall impact on the pipeline industry. Additionally, knowing that cyberattacks against pipeline systems are likely to increase, while equipment failure and corrosion incidents are likely to decrease, assists in predicting and preparing for future incidents.

References

1. Table 1-10: U.S. Oil and Gas Pipeline Mileage. Bureau of Transportation Statistics. (2013) Retrieved from http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_10.html (accessed January 12, 2016).
2. PHMSA Pipeline Incidents (1995-2014). Pipeline & Hazardous Materials Safety Administration. (2015). Retrieved from http://opsweb.phmsa.dot.gov/primis_pdm/all_reported_inc_trend.asp (accessed January 12, 2016).
3. Summary of Enforcement Actions. Pipeline & Hazardous Materials Safety Administration. (2015). Retrieved from http://primis.phmsa.dot.gov/comm/reports/enforce/Actions_opid_0.html?nocache=5767#_TP_1_tab_1 (accessed January 12, 2016).
4. Corrective Action Orders Issued. Pipeline & Hazardous Materials Safety Administration. (2015). Retrieved from http://primis.phmsa.dot.gov/comm/reports/enforce/CAOEvent_opid_0.html?nocache=7184 (accessed January 12, 2016).
5. Bluegreen Alliance. (2014, April 30). Repairing America's Aging Pipelines. Retrieved from http://www.bluegreenalliance.org/news/publications/NaturalGas_BiFold_R8_HighRes.pdf (accessed January 12, 2016).
6. Bell, T. E. (2014). Pipelines Safety And Security: Is It No More Than A Pipe Dream? The Bent of Tau Beta Pi. Winter 2015. Retrieved from http://www.tbp.org/pubs/Features/W15Bell.pdf (accessed January 12, 2016).
7. Fact Sheet: Other Outside Force. Pipeline & Hazardous Materials Safety Administration. (2014). Retrieved from http://primis.phmsa.dot.gov/comm/FactSheets/FSOtherOutsideForce.htm?nocache=3930 (accessed January 12, 2016).
8. Fact Sheet: Natural Force Damage. Pipeline & Hazardous Materials Safety Administration. (2014). Retrieved from http://primis.phmsa.dot.gov/comm/FactSheets/FSNaturalForce.htm?nocache=2515 (accessed January 12, 2016).
9. Fact Sheet: Excavation Damage. Pipeline & Hazardous Materials Safety Administration. (2014). Retrieved from https://primis.phmsa.dot.gov/comm/FactSheets/FSExcavationDamage.htm (accessed January 12, 2016).
10. Fact Sheet: Incorrect Operation. Pipeline & Hazardous Materials Safety Administration. (2014). Retrieved from http://primis.phmsa.dot.gov/comm/FactSheets/FSIncorrectOperation.htm?nocache=4528 (accessed January 12, 2016).
11. Sanger D. E. and Schmitt, E. (2012). Rise is Seen in Cyberattacks Targeting U.S. Infrastructure. The New York Times. Retrieved from http://www.nytimes.com/2012/07/27/us/cyberattacks-are-up-national-security-chief-says.html?_r=0 (accessed January 12, 2016).
12. Parfomak, P. W. (2012). Pipeline Cybersecurity:Federal Policy. Congressional Research Service. Retrieved from http://nsarchive.gwu.edu/NSAEBB/NSAEBB424/docs/Cyber-076.pdf (accessed January 12, 2016).
13. Hellman, H. (2015). Acknowledging the threat: Securing United States Pipeline SCADA Systems. Energy Law Journal, 36. Pg 157-178. Retrieved from http://felj.org/sites/default/files/docs/elj361/23-157-Hellmann-Final-4.27.pdf (accessed January 12, 2016).
14. National Security Council. Transnational Organized Crime: A Growing Threat to national and International Security. Retrieved from https://www.whitehouse.gov/administration/eop/nsc/transnational-crime/threat (accessed January 12, 2016).

Megacities Through the Lens of Social Media

By: Anthony Stefanidis, Ph.D., Andrew Jenkins, Arie Croitoru, Ph.D. & Andrew Crooks, Ph.D.



Urbanization and Megacities

Over the past half century, the worldwide urban population grew from 746 million in 1950 to 3.9 billion in 2014, and experts project the population will reach 5 billion in 2030 and 6.3 billion by 2050. [1] This growth is primarily due to a pronounced urbanization trend. While only one-third of the global population was urban in 1950 (29.5 percent), half (53.6 percent) of the global population is urban today and two-thirds (66.4 percent) is projected to be urban by 2030. This urbanization trend is uneven: it does not lead to *more* urban areas but rather to *bigger* metropolitan areas, with megacities [2] expected to grow at a faster pace than the rest of urban settlements.

Since the 1970s, the number of megacities more than tripled (from eight to 34), and is expected to further double until 2050 (to exceed 60). Almost all of these new megacities are emerging in geopolitical hotspots of the developing world, primarily in Southeast Asia and sub-Saharan Africa. [1,3] The U.S. Department of Defense, therefore, must consider the challenges presented by engagement in such environments when planning for its future.

In a recent article, Maj. Christopher Bowers drew analogies between the experiences of the U.S. Army operations in 2004 and 2008 in Sadr City (a Shiite-controlled impoverished suburb district of Baghdad) and the projected challenges of future operations in megacities. [4] He focused primarily on the challenges of scale, human terrain variations and governance. Indeed, the physical challenges of operating in such dense, highly three-dimensional, socially uneven and, often, ungovernable environments are immense.

However, and this is the key focus of this contribution, the advanced functional complexity of these large urban environments further compounds these challenges: megacities function at the intersection of the physical, social and

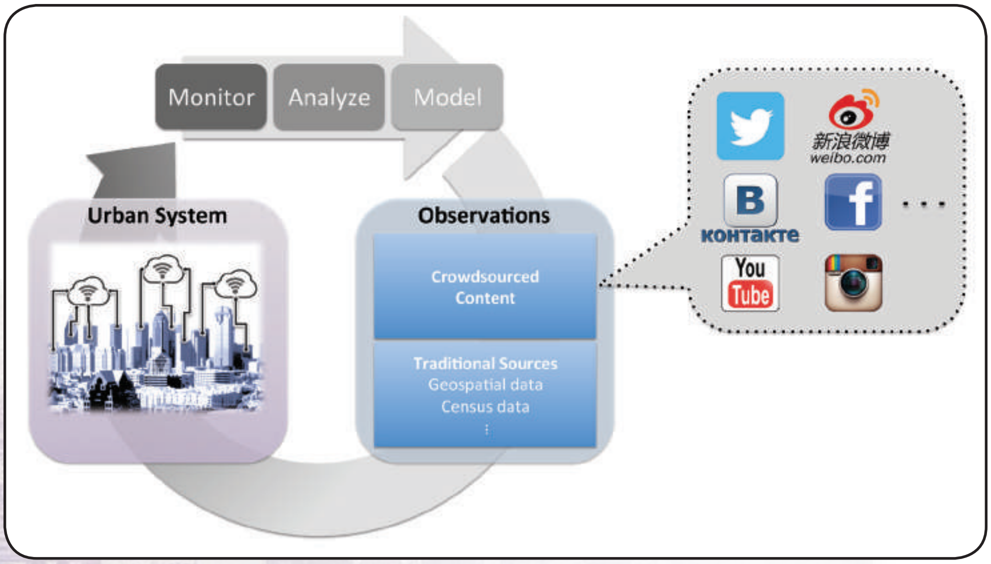


Figure 1. An emerging framework to study urban systems. (Released)

cyber spaces. Accordingly, military operations in these locations must be prepared to engage in environments where news, ideas and opinions are often shaped in cyberspace and propagated across the physical urban landscape. These processes lead to the formation and reformation of social networks to connect (or divide) populations, and facilitate the mobilization of these communities in response to ongoing events.

Across continents and events, from protests in the Arab world and disasters in the Far East, to reactions to terrorist activities in the West, social media has been the communication avenue of choice for the general public. [5,6] Advancing the capability to analyze crowd-generated content in the form of social media feeds is a substantial scientific challenge with considerable implications for future DoD operations.

Social Media and Intelligence

The term *social media* typically refers to services like Facebook, Twitter, Flickr and YouTube, which enable the general public to communicate with peers, sharing information instantly and constantly in an effortless and intuitive way. By bypassing the need for advanced computing skills to participate, and by fostering social interaction in cyber space, social media revolutionized information dissemination and presented

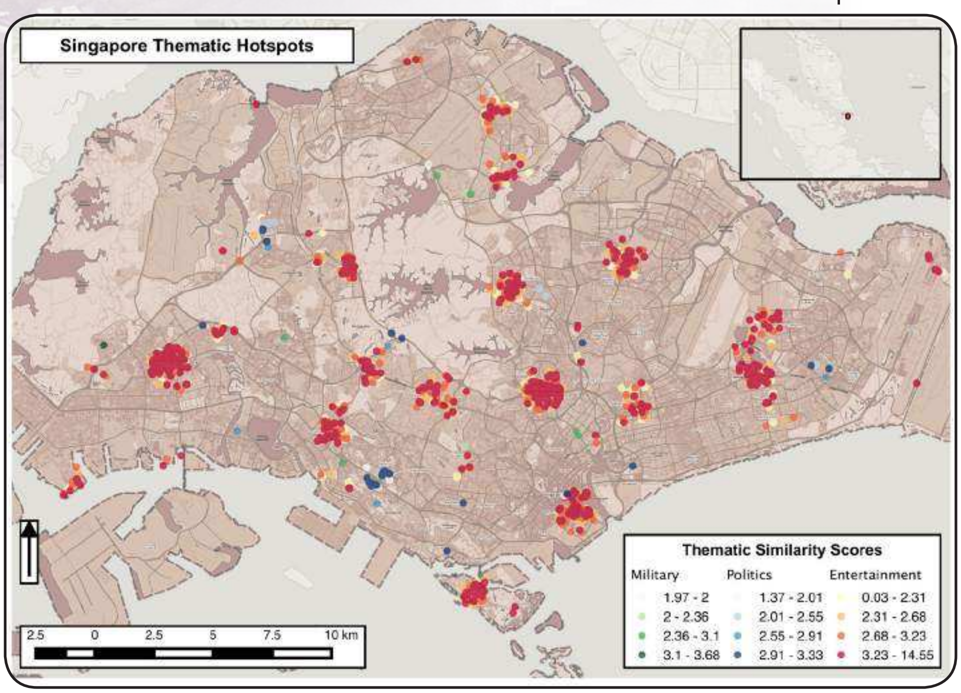


Figure 2. Sociocultural hotspots in Singapore detected through the classification of tweets originating from these locations: entertainment (shades of red), politics (shades of blue) and military (shades of green). (Released)

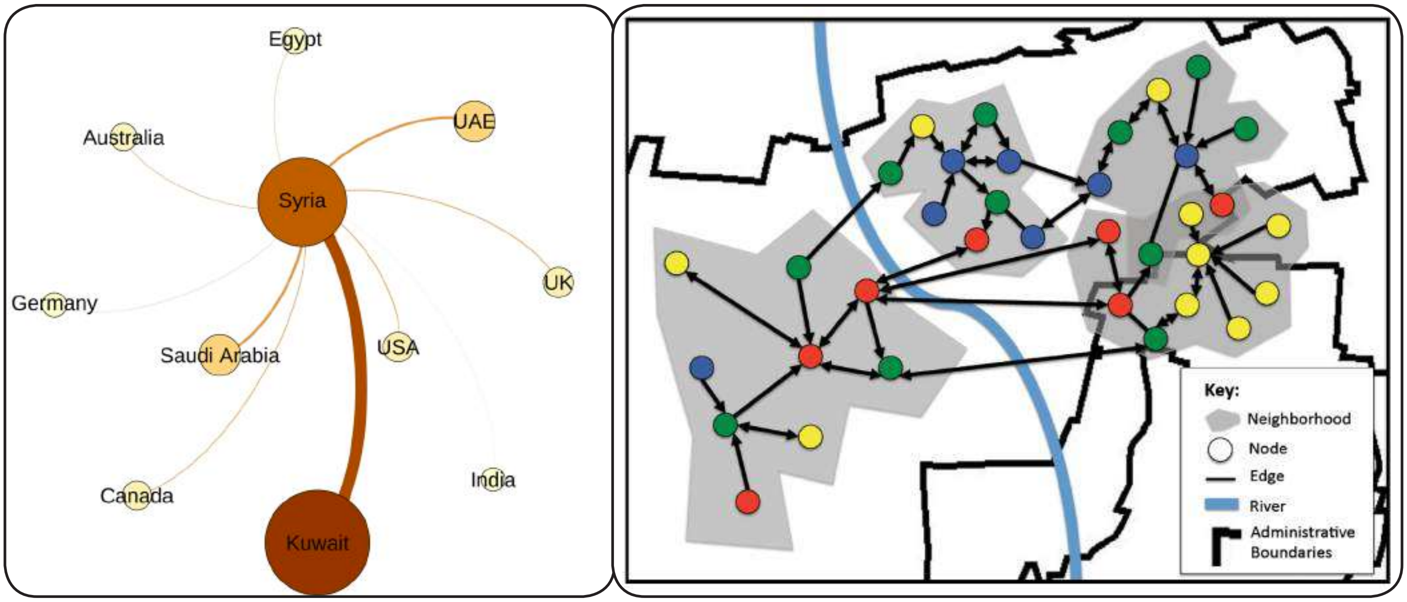


Figure 3. A (left): The discussion about Syria in Twitter. The size of the nodes indicates the level of participation by different international communities, proportional to the number of tweets originating from these countries normalized by the local populations. B (right): Social networks embedded within a geographical content, leading to connected, non-contiguous areas of operations. (Released)

an alternate means for community formation.

Today, Facebook has nearly 1.5 billion monthly active users worldwide (exceeding the populations of either China or India), while Instagram and Twitter have in excess of 400 and 300 million users respectively. [7] While these are global applications, there exist a number of regional services as well. For example, the Chinese instant messaging platform Tencent QQ exceeds 800 million active accounts, while the Russian VKontakte service has 100 million local active users. These communities contribute massive amounts of crowd-generated data. Every minute, more than 300,000 status updates are posted in Facebook and 450,000 new tweets are generated, while 65,000 new photos are uploaded in Instagram, [8] leading to the emergence of a new big data paradigm. [9]

Analyzing the content of these contributions is all about finding connection patterns. Connections among users (e.g., formed as they respond to, or follow, other users) reveal the underlying social structure of the user community. Word co-occurrences lead to the formation of semantic connections among the terms used in social media (e.g., words that are used commonly together in the context of a particular discussion), and in doing so reveal the complex narrative of this public discourse. Connections among locations (e.g., coordinates from which the contributions originate, or of references to specific locations) reveal the geographical footprint of various communities. It is through the analysis of these multiple connections that one can decode the convoluted content of social media feeds. This can be of interest to a variety of applications, including intelligence.

The significance of social media for intelligence was demonstrated quite vividly during the Arab Spring events across North Africa and the Middle East in early 2011. Platforms like Twitter, Facebook and YouTube were instrumental in reporting news from these events, [10] and in supporting the organization and coordination of related activities. [11] While this is widely considered a watershed moment for the use of social media in geopolitical events, it was not the first time this happened. Twenty months before the Arab Spring, in June 2009, social media platforms were used to broadcast to the world real-time information from the clashes in the streets of Teheran following the rigged Iranian presidential election, bypassing the state-imposed crackdown on crisis coverage. [11]

In the time since these first glimpses at their communication power, social media has been used in response to natural disasters and the Fukushima nuclear accident in the Far East; used to communicate information following terrorist attacks in the streets of Boston and Paris; and abused by the Islamic State of Iraq and the Levant in the Middle East. [12,13,14]

Decoding Urban Complexity through Social Media Analysis

With megacities emerging as theaters of events and operations, a new framework is needed for monitoring, analysis and modeling. Toward this goal, megacities are treated with an alternative view, as *information hubs*. Five years ago, in 2010, then Google CEO Eric Schmidt, pointed out the world was generating nearly five exabytes of data every two days, the equivalent of the sum of information generated by humanity from the dawn of civilization up until the beginning of this millennium. [15] Most of that information is generated in cities through smart devices (from traffic cameras to smart appliances) or from their residents (through their social media activities). Accordingly, operations in megacities are operations in information-rich environments.

A novel framework for studying megacities, therefore, must be characterized by the collaborative use of authoritative (e.g., mapping and cen-

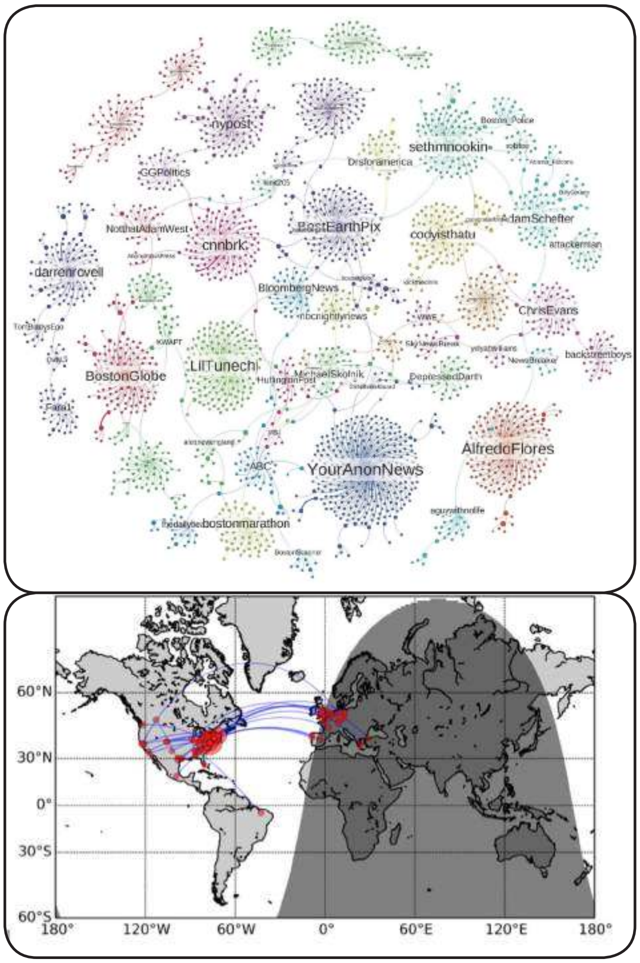


Figure 4. Top: A retweet network formed through interactions during the first 10 minutes after the Boston Marathon bombing of April 15, 2013. Bottom: The geographical distribution of these retweets. (Released)

sus data) and crowd-generated (e.g., content harvested from social media) content (see Figure 1). It is through the collaborative analysis of these data sources that one can fully capture the complex structure and functionality of these large urban areas. Some lessons learned from on-going studies in this emerging framework help us realize some notable particularities associated with operating in such information-rich environments and are listed below.

Cities Are More Complex Spaces Than Their Geometries

While the three-dimensional layout of a city remains important, cities cannot be viewed as pure geometrical spaces. Buildings and road networks enable and support certain actions and operations, and as such, it is critical to maintain the most up-to-date information for them; but cities are more than their geometries. Human activities and perceptions augment geometry by assigning to locations different sociocultural meaning, transforming these locations into places. While some of these places are well established and widely known (e.g., the theater district in Manhattan, or the artsy Bastille district in Paris), other places are more dynamic, occurring for example, temporarily, in response to particular events.

For example, Cairo's Tahrir Square gained a totally different meaning on Jan. 25, 2011, when it was occupied by 50,000 protesters, marking the beginning of the revolution against Hosni Mubarak's regime. [16] Capturing such information is becoming feasible through analyzing crowd-generated content.

Figure 2 shows different sociocultural hotspots in Singapore, detected by analyzing tweets originating from the city over a period of a month. Tweets were classified by analyzing their content into one of various thematic categories, and spatial clusters were identified to mark the corresponding hotspots—in this particular case, entertainment, politics and military.

In a similar manner, one could identify hotspots associated with other sociocultural issues that elicit public mentions in social media (e.g., health, finance) and at various levels of granularity (e.g., identifying references to a particular health issue as opposed to health at large). Through this process one could identify urban sociocultural hotspots. The aggregate of these hotspots is the equivalent of *semantic map of the city*, identifying meaningful sociocultural subdivisions and their variations over time. Through this process one can identify, for example, friendly or hostile areas and their evolution in response to certain events; hotspots for or against a certain issue; and even monitor the progress in space and through time of a civil unrest event. [17] Harvesting such local knowledge directly from crowd-generated content offers the additional advantage of eliminating the potential biases often associated with cross-cultural analysis.

Containment is Challenging in a Networked World

By substituting physical with virtual interaction, social media have introduced a novel avenue for community building, transcending established boundaries to diffuse ideas and information across space. This leads to the formation of highly-connected communities that are spatially distributed. As a result, an area of operations is no longer geometrically bound: the individuals operating within it may be connected (virtually, even though not physically) to other groups or individuals at distant locations, beyond the particular area of operations boundaries. Accordingly, events that occur at these distant locations may affect the area of operations, often in an unpredictable manner.

As an example, Figure 3 A shows the formation of an international community because of the discourse in Twitter regarding Syria. [18] Remote communities participate in this debate, influencing and being influenced by the local Syrian community. The effect of this process is to connect these remote locations, creating a virtual community that transcends space, comprising locals and foreigners alike.

From an operational standpoint this is visualized in Figure 3 B: three distinct neighborhoods, (the three disjointed gray blobs) are connected through the connections of individuals or groups within them (the colored nodes, with each color denoting a particular on-line community). While nodes within each neighborhood are connected (via spatial proximity) to other nodes within it, certain nodes are also connected (via social proximity) to distant nodes in the other neighborhoods. Accordingly, operations within each neighborhood would be affected by the events occurring in the rest, establishing a non-contiguous area of operations. Advancing the ability to identify these connections and gaining a better understanding of the footprint of an area of operations could lead to substantial operational benefits.

Information Authority is a New Challenge

In the new paradigm of information dissemination through social media information, authority is a challenge. Figure 4 shows the network of retweets (top) and its spatial distribution (bottom) of Twitter traffic during the first 10 minutes after the Boston Marathon bombing. The network of retweets captures the communities formed through retweet activities: once a user retweets a post, the user is connected to the original author. Through this process, communities emerge as node clusters, indicating groups of users that are sharing stories. Bigger communities (i.e. ones with larger membership) are more influential than smaller ones.

Figure 4 overlays upon each community cluster the name of its central node, i.e. a highly influential member for that community. It is interesting to observe that during this critical period the top news disseminating node was not an official government account: Boston Police is rather peripheral in the discussion, representing a relatively small community at the upper right-hand side of the graph.

Instead, the top news disseminating node then was the Twitter account of Anonymous (@YourAnonNews), surpassing even official news organizations (@cnnbrk, @nypost, @BostonGlobe) and the ever popular celebrities (@AlfredoFlores, @LilTunechi). This exemplifies the challenge of authority in this participatory information ecosystem: a large part of the population was getting its information from unvetted sources, and as such may be vulnerable to manipulative dissemination of misinformation.

Given the spatial footprint of these communities (Figure 4, bottom) one can easily realize this information may very well be provided by overseas accounts. To further emphasize this vulnerability, in the fall of 2014, Russian government-affiliated hackers tested their abilities to disseminate false information and spread panic. In September, 2014 the hackers used fake social media accounts to make up a fake story about a fictional disaster in a real chemical plant in Louisiana, and followed in December, 2014 with posts reporting a fake outbreak of Ebola in Atlanta. [19]

These challenges represent a new type of cybersecurity concern, where the issue is not denial of service (as is usually the case with traditional cybersecurity attacks) but rather the denial of information, or the spread of misinformation. Accordingly, operations in information-rich urban areas may be subject to such challenges, leading to highly volatile environments.

Conclusion

Megacities are challenging operational environments, as they function at the intersection of the physical, social and cyber spaces. By viewing them as information hubs, the DoD can gain a better understanding of the way in which they are organized and operate. Therefore, a novel approach for studying megacities is emerging, characterized by the collaborative use of authoritative and crowd-generated content.

Harvesting information from social media allows the military to capture the complex sociocultural multidimensionality and the multiple links that characterize these modern urban environments. It also offers the added advantage of gaining such knowledge directly from the local population. In this approach, data is an operational commodity. However, the immersion in such a data-rich framework comes at the cost of a challenged authority, with official government agencies enjoying only a limited presence compared to other leaders of the social media ecosystem. Refining analytical capabilities will help overcome this challenge and take full advantage of the presented opportunities.

References

1. United Nations (2014, July 10) World Urbanization Prospects: The 2014 Revision. UN Department of Economic and Social Affairs / Population Division. Retrieved from http://esa.un.org/unpd/wup/ (accessed January 13, 2016).
2. Oxford English Dictionary. The Definition of a Megacity (A city with a population of 10 million or more). Retrieved from http://www.oxforddictionaries.com/us/definition/american_english/megacity (accessed January 13, 2016).
3. Pasick, A. (2014, July 11) Almost all of the world's largest cities will be in Asia and Africa by 2030. Retrieved from http://qz.com/233334/almost-all-of-the-worlds-biggest-cities-will-be-in-asia-and-africa-by-2030/ (accessed January 13, 2016).
4. Bowers, C. O. (2015). Future Megacity Operations—Lessons from Sadr City. Military Review. Retrieved from http://usacac.army.mil/CAC2/MilitaryReview/Archives/English/MilitaryReview_20150630_art006.pdf (accessed January 13, 2016).
5. Gerbaudo, P (2012). Tweets and the streets: Social Media and contemporary activism. London, England; Pluto Press.
6. Gao, H, Barbier, B., & Goolsby, R. (2011). Harnessing the crowdsourcing power of social media for disaster relief. IEEE Intelligent Systems, (3), 10-14. Retrieved from http://star-tides.net/sites/default/files/documents/files/Harnessing-the-Crowdsourcins-Power-of-Social-Media-for-Disaster-Relief.pdf (accessed January 13, 2016).
7. Statista.com. (2015, November 1). Leading social networks worldwide as of November 2015, ranked by number of active users (in millions). Retrieved from http://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/ (accessed January 13, 2016).
8. ThinkToStart.com. (2015, August 25). How much data is generated every minute on top digital and social media? Retrieved from http://thinktostart.com/how-much-big-data-is-generated-every-minute-on-top-digital-and-social-media-infographic/ (accessed January 13, 2016).
9. Croitoru, A., Crooks, A. T., Radzikowski, J., Stefanidis, A., Vatsavai, R. R., & Wayant, N. (2014). Geoinformatics and social media: A new big data challenge. Big Data Techniques and Technologies in Geoinformatics, CRC Press, Boca Raton, FL, 207-232.
10. Shane, S. (2011 January 29). Spotlight again falls on web tools and change. The New York Times. Retrieved from http://www.nytimes.com/2011/01/30/weekinreview/30shane.html?_r=1&hp (accessed January 13, 2016).
11. Pollock, J. (2011, September/October), Streetbook: How Egyptian and Tunisian Youth Hacked the Arab Spring. Technology Review. Re-

trieved from http://www.technologyreview.com/web/38379/ (accessed January 13, 2016).

12. Stefanidis, A., Crooks, A., & Radzikowski, J. (2013). Harvesting ambient geospatial information from social media feeds. GeoJournal, 78(2), 319-338. Retrieved from http://link.springer.com/article/10.1007%2Fs10708-011-9438-2#/page-1 (accessed January 13, 2016). doi: 10.1007/s10708-011-9438-2
13. Rosen, R. (2015, November 13) Heavy.com. "They are slaughtering everyone..one by one." Hostage posts to Facebook during Paris attack. Retrieved from] http://heavy.com/news/2015/11/paris-attack-bombing-hostage-post-social-media-facebook-twitter-benjamin-cazenoves-bataclan-eagles-death-metal/ (accessed January 13, 2016).
14. J Berger, J Morgan, (2015, March) Brookings.com. The ISIS Twitter Census: Defining and describing the population of ISIS supporters on Twitter. Retrieved from http://www.brookings.edu/research/papers/2015/03/isis-twitter-census-berger-morgan (accessed January 13, 2016).
15. Siegler, M.G. (2010, August 4). Techcrunch.com. Eric Schmidt: Every two days we create as much information as we did up to 2003. Retrieved from http://techcrunch.com/2010/08/04/schmidt-data/ (accessed January 13, 2016).
16. Aboelezz, M. (2014). The Geosemiotics of Tahrir Square: A study of the relationship between discourse and space. Journal of Language and Politics. 13(4), 599-622. Retrieved from https://benjamins.com/#catalog/journals/jlp.13.4.02abo/details (accessed January, 13, 2016). doi:10.1075/jlp.13.4.02abo
17. Croitoru, A., Wayant, N., Crooks, A., Radzikowski, J., & Stefanidis, A. (2015). Linking cyber and physical spaces through community detection and clustering in social media feeds. Computers, Environment and Urban Systems. 53: 47-64. doi: 10.1016/j.compenvurbsys.2014.11.002
18. Stefanidis, A., Cotnoir, A., Croitoru, A., Crooks, A., Rice, M., & Radzikowski, J. (2013). Demarcating new boundaries: mapping virtual polycentric communities through social media content. Cartography and Geographic Information Science, 40(2), 116-129. Retrieved from http://css.gmu.edu/andrew/pubs/CaGIS.pdf (accessed January 13, 2016). doi: 10.1080/15230406.2013.776211
19. Chen, A. (2015, June 2) The agency. The New York Times. Retrieved from http://www.nytimes.com/2015/06/07/magazine/the-agency.html?_r=0 (accessed January 13, 2016).

Anthony Stefanidis, Ph.D., is a professor and chair of the Department of Geography and Geoinformation Science at George Mason University and the director of Mason's Center for Geospatial Intelligence. His research focuses on harvesting geospatial intelligence from social multimedia and other open-source content and on digital image analysis. Some of his work on social media analysis is featured in http://geosocial.gmu.edu/.

Andrew Jenkins is a Ph.D. candidate in the Department of Geography and Geographic Information Science at George Mason University. His research focuses on the study of places through the mining of crowdsourced semantic-spatiotemporal content. He holds degrees in Geoinformatics and Geospatial Intelligence (M.S.) and Computer and Information Science (B.S.). Jenkins also works as a Senior Data Scientist in the private sector supporting the DoD. His previous activities include work as a civilian researcher at the U.S. Army Engineer Research and Development Center, preceded by seven years in the U.S. Army active duty with multiple deployments to Iraq and Afghanistan.

Arie Croitoru, Ph.D., is an associate professor in the Department of Geography and Geoinformation Science at George Mason University. He is also a researcher at Mason's Center for Geospatial Intelligence. His research focuses on the development of algorithms and tools for extracting spatial information and knowledge from social media as well as other crowdsourced data.

Andrew Crooks, Ph.D., is an associate professor in the Department of Computational and Data Sciences at George Mason University. His research focuses on exploring and understanding the natural and socio-economic environments specifically urban areas using geographic information systems, spatial analysis, social network analysis and agent-based modeling methodologies.

Sprayable Foam

Limiting Blood Loss on the BATTLEFIELD

By: Matthew Dowling, Ph.D.

Combat survivability is at an all-time high, however caring for the wounded on the battlefield is an ongoing challenge for military forces. The ability to quickly stabilize the injured on-site increases the likelihood of successful treatment and transport to a medical facility. Between 2001 and 2011, hemorrhage, or uncontrolled blood loss, represented more than 80 percent of potentially survivable battlefield deaths. [1] With improved medical technologies and techniques, hemorrhage control and survivability could significantly increase.

Non-compressible injuries are difficult for field medics to control, and therefore, the majority of deaths occur before transporting the patient to a hospital. [2,3] The current protocol for field treatment of hemorrhage, according to Tactical Combat Casualty Care guidelines, is to apply tourniquets and other topical agents, such as Combat Gauze, to the affected area. [4] Topical hemostatic sealants may be used as adjuncts in cases where conventional measures for bleeding control fail, but the majority of these products are bandages or powders that require compression and wound visibility. [5] These attributes make the protocol products ineffective in treating non-compressible wounds, such as those in the groin or neck. [6]

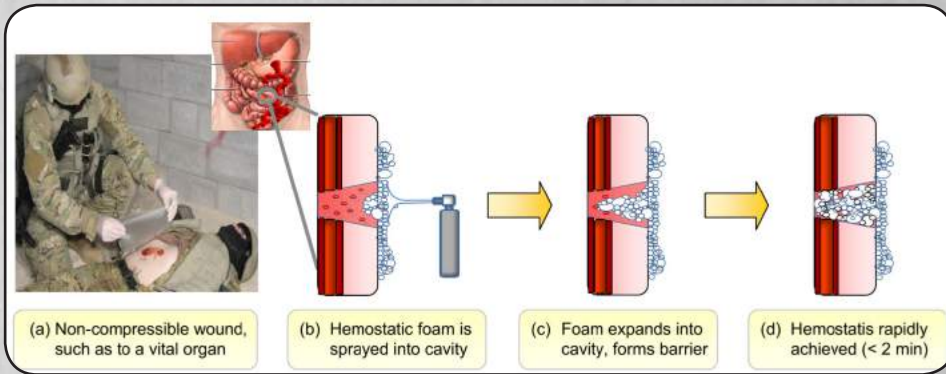


Figure 1. Concept of a hemostatic foam to treat non-compressible hemorrhage. Hemorrhage occurring from a wound in the truncal area, as shown in (a), cannot be treated by applying compression of a bandage. In this case, it is envisioned that a hemostatic foam can be sprayed into the wound cavity (b). The foam expands into the cavity and forms a solid barrier that counteracts the expulsion of blood (c). Active ingredients in the foam can also interact with the blood, promoting blood clotting or gelation. The net result is that hemostasis is rapidly achieved and the bleeding is thereby contained (d). (Released)

The capability gap is evident. The Defense Health Agency is currently assessing technologies to address the unmet medical need of hemorrhage control. [7] The lack of a readily available capability for non-compressible hemorrhage is a high research priority for the Department of Defense. [8]

When wounded, the body naturally begins the healing process by clotting the blood. A network of proteins comes together to form an insoluble barrier, preventing further blood loss. [9]

Many experiments on alternate clotting technologies, such as fibrinogen-coated albumin microparticles, thrombin-based hemostatic agents, lyophilized platelets and conjugated red blood cells, show insignificant outcomes on both compressible and non-compressible hemorrhage wounds. [10,11] These experimental hemostatic agents were not only ineffective, but expensive, required refrigeration and, in some cases, caused septicemia. [12]

Currently available products, such as proteins and aluminosilicates, contain significant challenges for use in military environments. Protein formulations are expensive and degrade in hot climates, making them impractical for use in current theaters of operation, such as Iraq and Afghanistan. [13] Aluminosilicates are inexpensive, but may be toxic and cause permanent tissue damage when administered. [14]

Scientists created an artificial clotting process that mimics natural clotting principles. The research resulted in the development of a hemostatic bandage that will stop the flow of blood. This development, if implemented in both military and civilian trauma centers, will increase survivability. [15]

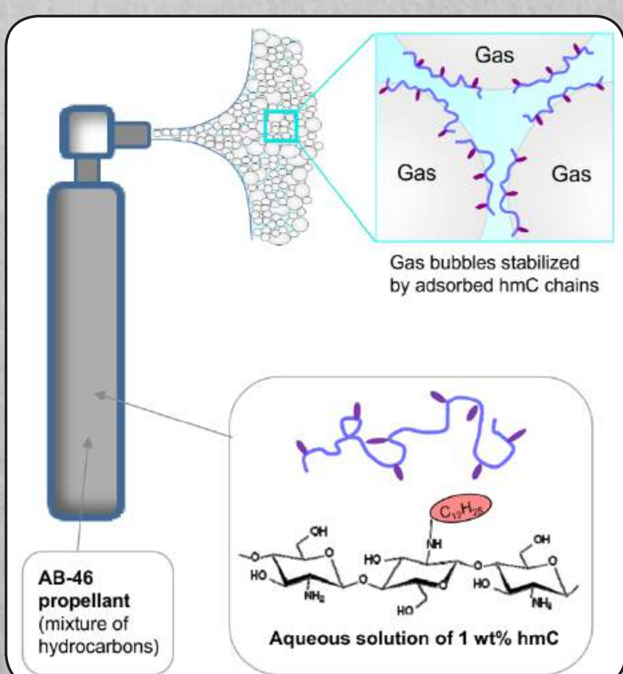


Figure 2. Hemostatic foams based on hmC. The foam is created by loading an aqueous solution of hmC and propellant into an aluminum canister. The structure of hmC (with C12 hydrophobes) is shown in the inset. The molecules are schematically represented by a blue (hydrophilic) backbone and purple hydrophobes attached to the backbone. When the actuator on the canister is pressed, a gas-in-liquid foam emerges. The gas bubbles in the foam are stabilized by adsorbed hmC chains, as shown in the inset. Note that the hydrophobes from these chains are oriented towards the gas phase while the hydrophilic backbone is oriented towards the aqueous liquid phase. (Released)

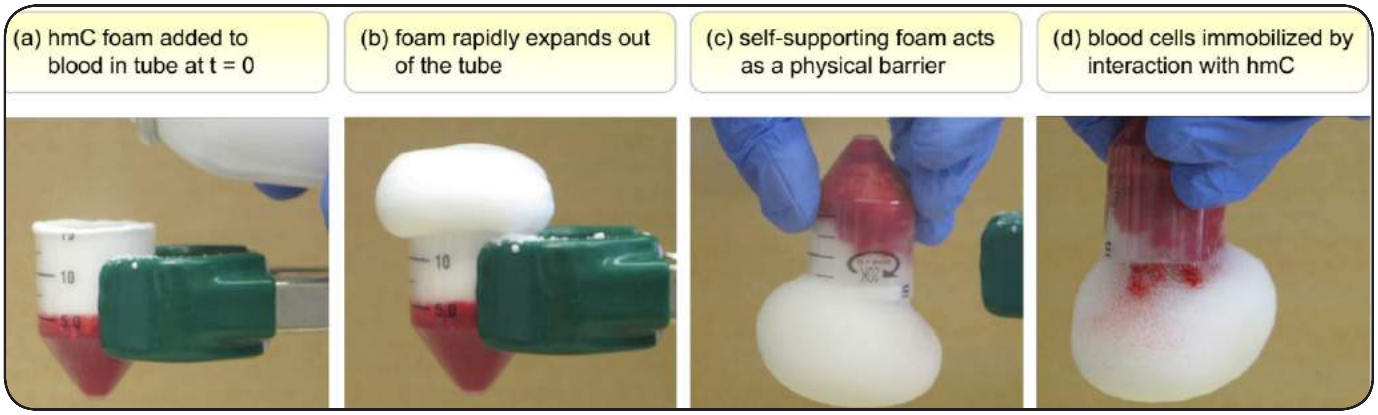


Figure 3. Immobilization of blood by hmC foam. At time t = 0, the foam of hmC ((5 mol% of C12 hydrophobes) is introduced into a tube containing 5 mL of heparinized bovine blood (a). The foam rapidly expands and overflows out of the tube (b). The self-supporting nature of the foam allows it to act as a physical barrier to blood flow due to gravity (c). In addition, the interaction of blood cells with the active ingredient (hmC) leads to the clustering of blood cells (see text and Figure 6) and thereby to the containment and immobilization of blood (d). (Released)

Additionally, scientists developed a hemostatic foam, which uses a compound of widely available and cost effective naturally occurring biopolymers. [16] The foam uses chitosan, the second most abundant biopolymer on earth, which functions similarly to the natural healing process. [17] Chitosan is a polysaccharide, obtained by modifying chitin, a naturally occurring compound found in crustaceans. [18] Scientists add hydrophobic tails, creating a hydrophobically modified chitosan, which allows the biopolymer to self-assemble into gel-like physical seals upon contact with blood. [15] The blood cells integrate into a matrix connected by the hm-chitosan, creating a gel network to stop the blood flow. The gelation activates only at the contacting interface of the wound site; therefore, the hm-chitosan will not cause clotting in undesirable areas of the body. [15] The blood cells agglutinate rapidly into a large 3-dimensional network, creating a gel that forms a strong bond and inhibits bleeding. [19]

Once at the hospital, medical personnel remove the hemostatic patch by adding α-cyclodextrin, which reverses the hemostatic gel and neutralizes the foam, rendering the hydrophobic properties of the hm-chitosan ineffective. [19]

Hm-chitosan is used commercially as a compressible hemostatic agent, but aerosolized hemostatic foam has not been utilized. [20] The hm-chitosan-modified aerosol produces a foam dispensed from a standard, lightweight, pressurized aluminum canister, making it a practical tool for field medics. The compact canister does not require refrigeration and does not expire. [20] Soldiers would be able to carry the products and treat wounds onsite, speeding response time and improving survivability. In addition, the foam could potentially

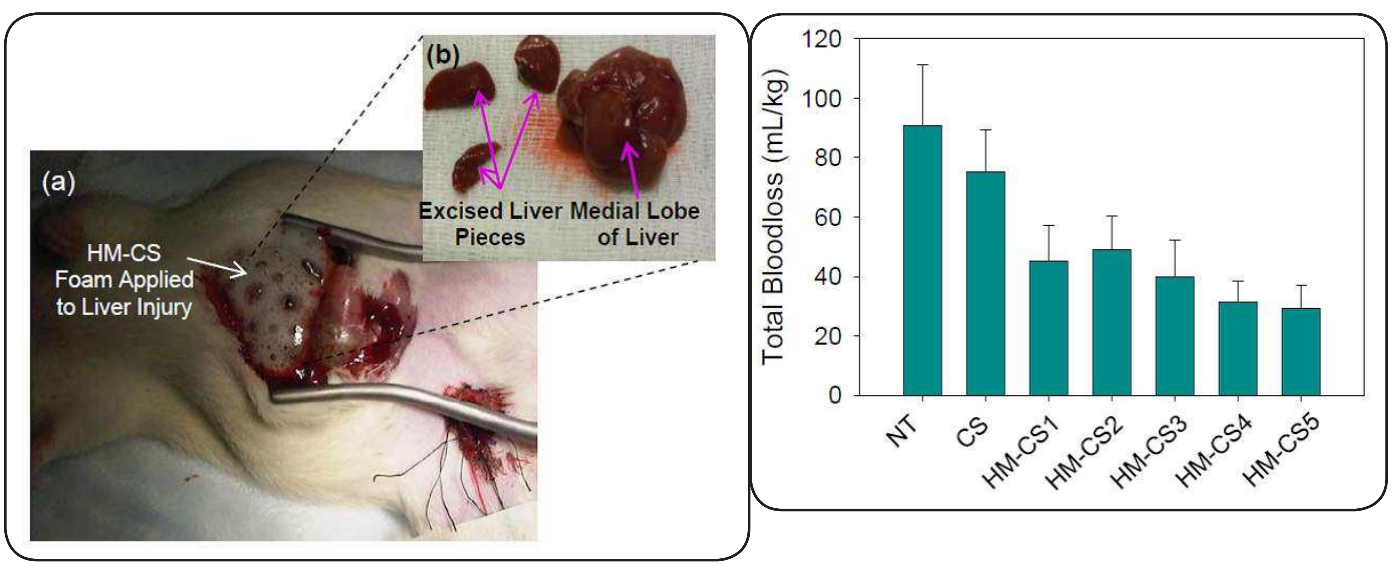


Figure 4. Photomicrograph of blood mixed with HM-CS foam. In 4a, a photograph of HM-CS foam filling the peritoneal cavity after application to the injured site is shown. Fig 4b shows a post-mortem image of the excised pieces of liver juxtaposed to the remaining medial lobe of the liver. In the histogram in 4c, total blood loss from each sample group is displayed. (Released)

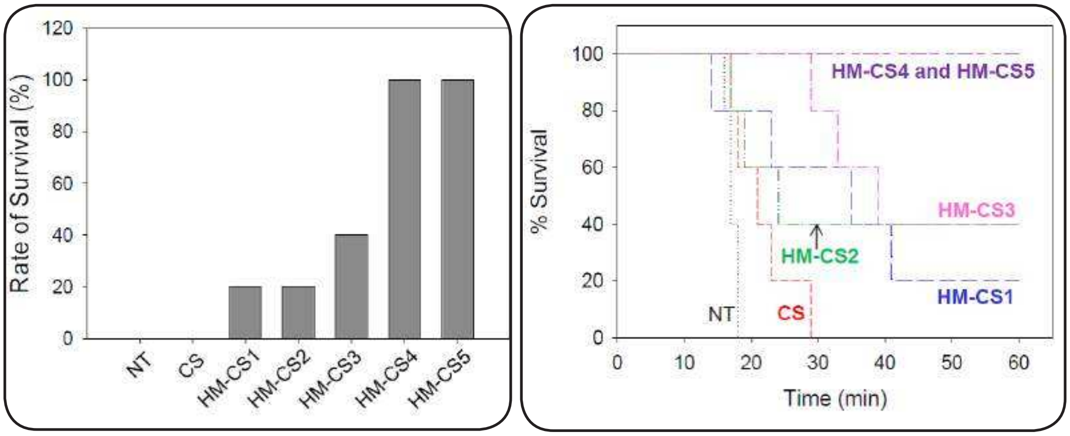


Figure 5. In 5a (left), survival rate from rat liver injury is shown. No treatment (NT) and chitosan (CS) controls resulted in 0% survival, with deaths occurring ~20 min after injury. All HM-CS had recorded occurrences of survival at 60 minutes: HM-CS1 (1/5), HM-CS2 (1/5), HM-CS3 (2/5), HM-CS4 (5/5), and HM-CS5 (5/5). The samples with the highest level of hydrophobicitiy, HM-CS4 and HM-CS5, achieved the highest rates of survival. In 5b (right), a Kaplan-Meier Analysis of HM-CS foams on the injury is shown. (Released)

be self-administered. [21]

Because of its self-expanding properties, the hemostatic foam fills the cavities of non-compressible wounds rapidly, reducing blood loss and improving survival. The foam uses the same principles of hm-chitosan by converting the liquid blood into a self-supporting gel.

In pre-trial tests, the foam lessened blood loss from a non-compressible bleed in a pig liver. In the experiment, scientists allowed the liver to bleed for one minute. After one minute, they applied the foam to the injury site, monitored the site for hemostasis and recorded the total blood loss. Different concentrations (5 percent, 2.5 percent and 1 percent of available amines along the chitosan backbone) of hydrophobic modifications to the chitosan foam were tested. [22]

Hemostasis was achieved immediately and sustained over the duration of the experiment with hm-chitosan foams. The experiments' results showed the 5 percent hydrophobically-modified chitosan foam was the most effective, decreasing blood loss by 90 percent. [23] The hydrophobes increase stability and promote interaction between the hm-chitosan foam and the blood cells at the injury site, while showing no significant toxicity to the cells. [20]

The ability to control blood loss on the battlefield will be a significant factor in increasing survivability of wounded soldiers. The use of an aerosolized hemostatic foam agent will, additionally, meet the DoD's requirements for a cost-effective, easy to use and resilient technology.

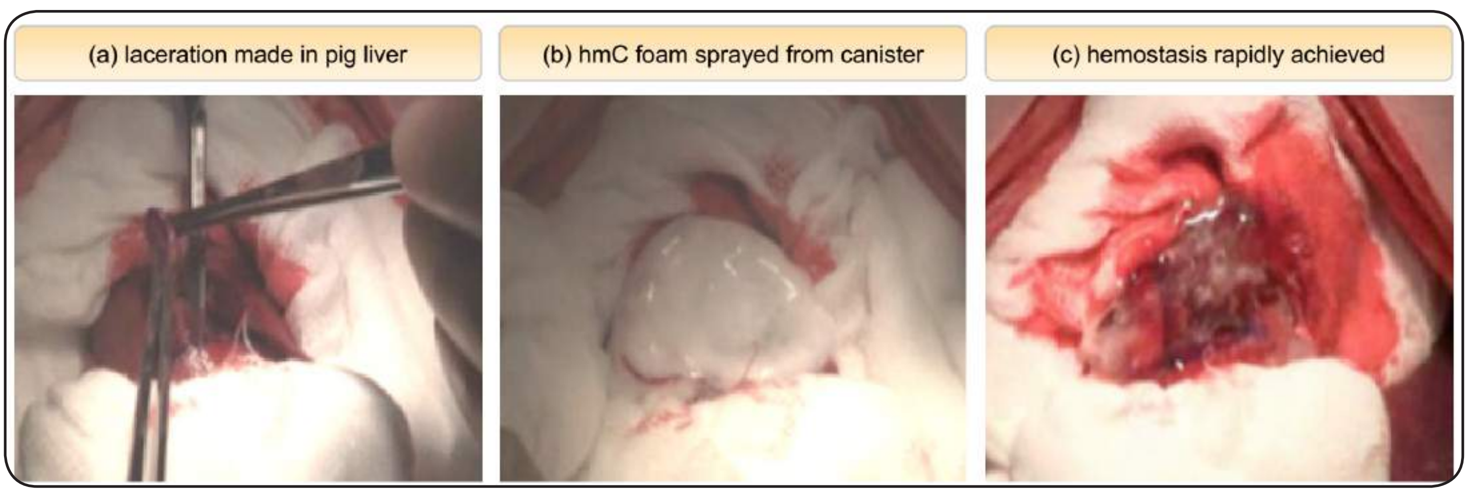


Figure 6. Testing the hemostatic efficacy of hmC foams against a pig liver injury. Initially, a laceration is made in the liver of the pig using a scalpel (a). After 1 min of free bleeding, the hmC foam is sprayed onto the injury site from the canister (b). No compression is used. The injury is monitored thereafter and the total blood loss is measured. We find that hemostasis is achieved rapidly and sustained for the course of the experiment, as shown by (c). The results indicate that hmC foams can successfully treat hemorrhage without the need for compression. (Released)

References

1. Kime, P. (2013, March 29). Study: 25 % of war deaths medically preventable. Army Times, 21-22. http://archive.armytimes.com/article/20120628/NEWS/206280315/Study-25-war-deaths-medically-preventable (accessed January 28, 2016).
2. Kelly, J. F., Ritenour, A. E., Mclaughlin, D. F., Bagg, K. A., Apodaca, A. N., Mallak, C. T., . . . Holcomb, J. B. (2008). Injury Severity and Causes of Death From Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 Versus 2006. The Journal of Trauma: Injury, Infection, and Critical Care, 64(Supplement).
3. Kotwal, R. S. (2011). Eliminating Preventable Death on the Battlefield. Arch Surg Archives of Surgery, 146(12), 1350.
4. Kotwal, R.S. et al. (2014). The Tactical Combat Casualty Care Casualty Card. TCCC Guidelines. http://www.chinookmed.com/TCCC-Change-Prop-1301-TCCC-Card.pdf (accessed January 28, 2016).
5. Glick, J.B. et al. (2013). Achieving Hemostasis in Dermatology—Part II: Topical Hemostatic Agents. Indian Dermatology Online Journal, 4(3): 172-176. Doi: 10.4103/2229-5178.115509
6. Cobden, R.H. et al. (1976). Topical Hemostatic Agents to Reduce Bleeding from Cancellous Bone. A Comparison of Microcrystalline Collagen, Thrombin, and Thrombin-soaked Gelatin Foam. Journal of Bone and Joint Surgery American Volume, 58(1): 70-73.
7. Pusateri, A.E. (2014). Unmet Medical needs in Prehospital Hemorrhage Control: DoD Perspective. Defense Health Agency. http://www.fda.gov/downloads/MedicalDevices/NewsEvents/WorkshopsConferences/UCM415997.pdf (accessed January 28, 2016).
8. Eastridge, BJ, et al. (2011). Died of Wounds on the Battlefield: Causation and implications for Improving Combat Casualty Care. J Trauma, 71(1 Supplement): S4-8.
9. Saito, H., Matsushita, T., & Kojima, T. (2011). Historical perspective and future direction of coagulation research. Journal of Thrombosis and Haemostasis, 9(1), 352-363. doi:10.1111/j.1538-7836.2011.04362
10. Beekley AC, Sebesta JA, Blackbourne LH, et al. Prehospital tourniquet use in operation Iraqi Freedom: effect on hemorrhage control and outcomes. J Trauma 2008;64:S28.
11. Hawksworth JS, Elster EA, Fryer D, et al. Evaluation of lyophilized platelets as an infusible hemostatic agent in experimental non-compressible hemorrhage in swine. Journal of Thrombosis and Haemostasis 2009; 7, 1663-1671
12. Wilsonson, W.C., Grande, C.M., and Hoyt, D.B. (2007). Trauma: Resuscitation, Perioperative Management and Critical Care. Taylor and Francis Group: New York.
13. Camp, M.A. (2014). Hemostatic Agents: A Guide to Safe Practice for Perioperative Nurses. AORN Journal, 100(2): 131-147. DOI: http://dx.doi.org/10.1016/j.aorn.2014.01.024
14. Savitsky, E., ed. Combat Casualty Care: Lessons Learned from OEF and OIF. Office of the Surgeon General, Department of the Army. 2012.
15. Dowling, M., Kumar, R., Keibler, M., Hess, J., Bochicchio, G., & Raghavan, S. (2011). A self-assembling hydrophobically modified chitosan capable of reversible hemostatic action. Biomaterials, 32(13), 3351-3357. doi:10.1016/j.biomaterials.2010.12.033
16. Ige, O.O. et al. (2012). Natural Products: A Minefield of Biomaterials. International Scholarly Research Notices, Materials Science, Article ID 983062, 20 pages. doi: 10.5402/2012/983062
17. Bochicchio, G. et al. (2009). Use of a Modification Chitosan dressing in a Hypothermic Coagulaopathic Grade V Liver Injury Model. The American Journal of Surgery, 198(5): 617-622. doi: 10.1016/j.amjsurg.2009.07.028
18. Lewandowska, K. (2015). Characterization of chitosan composites with synthetic polymers and inorganic additives. International Journal of Biological Macromolecules, 81, 159-164. doi: 10.1016/j.ijbiomac.2015.08.003
19. Philippova, O.E. and Korchagina, E.V. (2012). Chitosan and Its Hydrophobic Derivatives: Preparation and Aggregation in Dilute Aqueous Solutions. Polymer Science, Ser.A, 54(7): 552-572. doi: 10.1134/S0965545X12060107
20. Dowling, M.B. et al. (2015). Hydrophobically-modified Chitosan Foam: Description and Hemostatic Efficacy. Journal of Surgical Research, 193(1): 316-323. doi: 10.1016/j.jss.2014.06.019'
21. Rago, A.P., Duggan, M.J., Hannett, P., et al. (2015). Chronic Safety Assessment of Hemostatic Self-expanding Foam: 90-day Survival Study and Intramuscular Biocompatibility. Journal of Trauma Acute Care Surgery, 79(4 Supplement 2): S78-8. doi: 10.1097/TA.0000000000000571
22. Peng, Tao. (2010). Biomaterials for Hemorrhage Control. Trends in Biomaterials and Artificial Organs, 24(1): 27-68. http://medind.nic.in/taa/t10/i1/taat10i1p27.pdf (accessed January 28, 2016).
23. Department of Health and Human Services. Hemogrip Patch Premarket Notification. http://www.accessdata.fda.gov/cdrh_docs/pdf14/K143466.pdf (accessed January 28, 2016).

Matthew Dowling, Ph.D., is the CEO and co-founder of Remedium Technologies. Dowling completed his graduate work at the Fischell Department of Bioengineering at the University of Maryland in May 2010 and has since pursued RTI on a full-time basis. In 2005, he was awarded the Fischell Fellowship in Biomedical Engineering for his ideas for commercially viable drug delivery systems after graduating in chemical engineering at the University of Notre Dame. At UMD, he developed the platform Hemogrip™ technology, which acts as the cornerstone of Remedium's R&D pipeline for hemostasis and wound healing products.

Hydrogels in Biomedical Applications

The Homeland Defense and Security Information Analysis Center recently conducted research and analysis on possible Department of Defense applications for chondroitin sulfate glycosaminoglycan hydrogels.

Background

CS-GAG hydrogels are a modification of hyaluronic acid. HA, found naturally in the human body, is produced in the plasma membrane of vertebrate cells. [1] HA hydrogels have been used successfully in cell delivery and many other biomedical applications. [2] Modification of natural HA to create CS-GAG hydrogels includes chemically adding additional sulfate groups to enhance their durability within the body. [3] Commonly used in cell delivery or transplant applications, hydrogels are successful because they have properties similar to surrounding tissue, which prevents rejection by the body. [3] The CS-GAG hydrogels create a matrix that encapsulates target cells to transplant into the body. [3]

Traumatic Brain Injury

Understanding the interdependencies among different neurological disorders bridges the gap between research and treatment. Traumatic brain injury is a neurological disorder closely correlated with post-traumatic stress disorder. [4] According to a study funded by the U.S. Office of Veterans Affairs, at least 20 percent of Iraq and Afghanistan veterans suffer from PTSD. The number more than doubles, however, when TBI is considered. [5] Addressing and treating neurological damage can help promote the treatment of psychological disorders. [6] HDIAC identified the benefits of using CS-GAG hydrogels to repair neurological damage after TBI so that it may help alleviate PTSD.

CS-GAG hydrogels have neural stem cells integrated in the matrix for treating TBI. [3] There is an increase in the incidence of TBI among active duty U.S. military personnel due to heavy use of improvised explosive devices.

HDIAC identified a capability gap and recommended solutions and further uses for CS-GAG hydrogels. Statistics show 92 percent of TBI incidents are mild to moderate. Severe TBI, the target demographic for treatment with CS-GAG hydrogel, is approximately 8 percent of total cases. [7]

Research indicates treatment gaps in mild TBI cases, which are the most common. By focusing on the use of CS-GAG hydrogel in the most severe occurrences, researchers eliminate 92 percent of potential patients. [8] The CS-GAG hydrogels have innovative properties that prevent their degradation by enzyme, allowing them to remain in the body and extend the time stem cells have to generate and grow. [3] In addition, CS-GAG hydrogels have anti-inflammatory factors, so they are safe to use in the brain and do not cause additional swelling. [3]

Vision

HDIAC's analyses included DoD applications that will benefit servicemen as well as civilians. There is a neurological connection between the eye and the brain, thus TBI may affect vision. [9] Among service members who served in Operations Enduring Freedom and Iraqi Freedom, eye trauma is the second most common injury and 75 percent of TBI patients experience vision problems. [10] Hyaluronic acid is a natural wound healer, and is found as a component of eye tissue. [11] Traditionally, drug carriers have not been successful in the eye because they are unable to maintain localized sustained release of drugs. [12] CS-GAG hydrogel degrades at a slower rate than HA hydrogels, and thus, is a better solution for drug delivery to the eye.

Hearing

HDIAC highlighted some additional areas of research where CS-GAG hydrogels would greatly benefit and extend current research. Hearing impairment is the most common form of service-connected disability among military veterans and one of the more common sensory losses resulting from blast trauma. [13,14] The inner ear hair cells transform sounds into electrical signals, which are sent to the brain for interpretation. Damage to these cells by loud noises, as would be common on the battlefield, can cause hearing impairment or even deafness. [14] HDAIC made the connection between the similarities of the inner ear hair cells and neural stem cells. Inner ear hair cells are non-regenerative, but neural stem cells have similar characteristics and are able to reestablish some auditory contacts, making them a potential replacement. [14]

Developing effective inner ear hair cells from neural stem cells is difficult due to the nervous integration of these cells. [14] The hydrogel's ability to enhance trophic factors, molecules that allow a neuron to develop and maintain connections, [15] could be beneficial in overcoming this obstacle.

Knee Injury

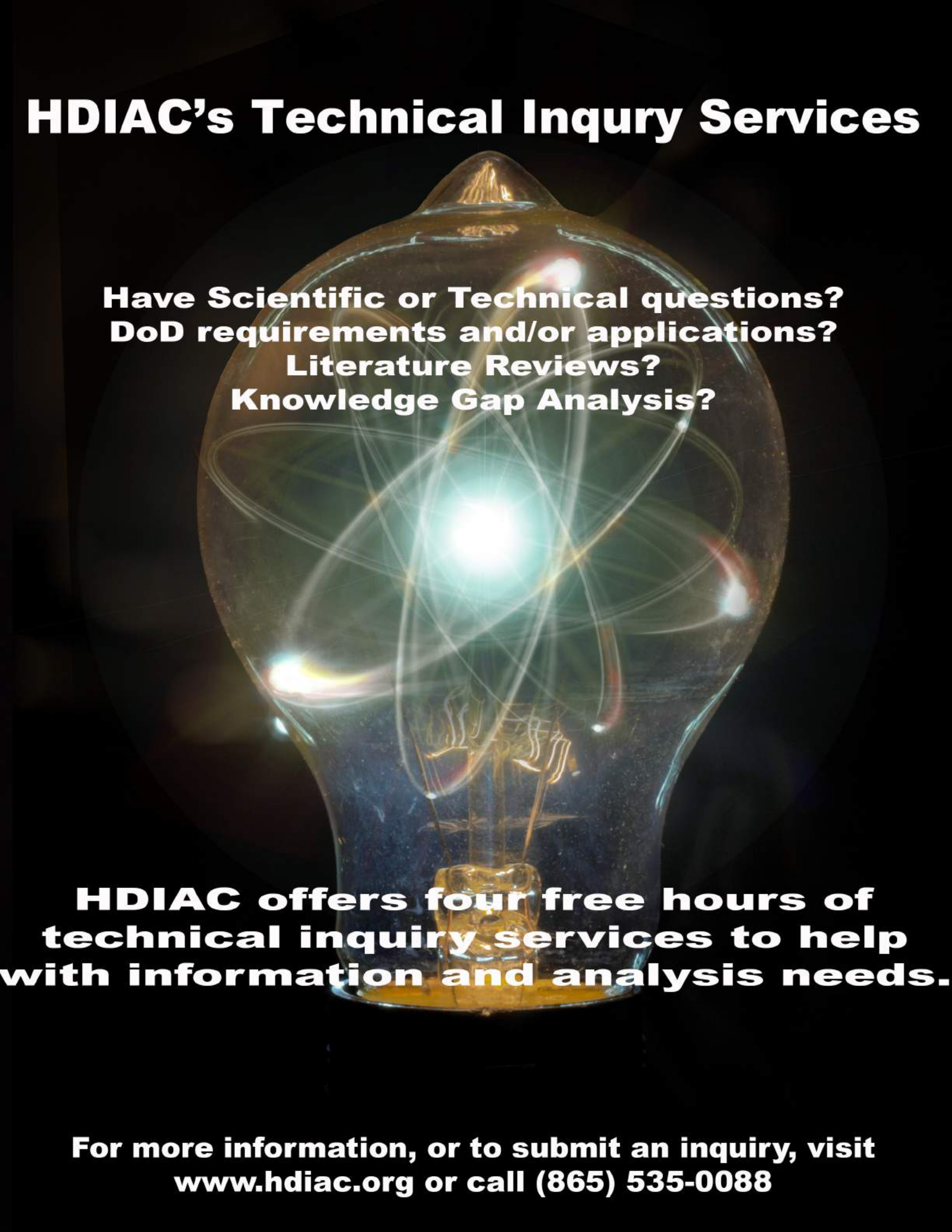
HDIAC recognized that rigorous physical training associated with the U.S. Army, and in-the-field complications, makes knee injuries among the most common musculoskeletal injuries in the Army, and connected these statistics to the research done with CS-GAG hydrogels. [16] Normal wear and tear of knee cartilage causes pain and loss of functionality and tissue engineering can be employed as a potential treatment. Tissue engineering mainly focuses on developing tissue and organ substitutes. [17] Clinical methods are limited in their cartilage tissue regeneration, thus tissue regeneration with Sulfated CS-GAG can be a viable solution. Hydrogels alone lack the robustness required for many applications [18] but Sulfated CS-GAG in conjunction with growth factors can be used as a matrix to promote cartilage regeneration, a challenge not yet achieved. [19]

Conclusion

The need for biomimetic research, like that of CS-GAG hydrogels, will continue to prove themselves multifunctional. Longitudinal studies and trend analysis will determine future growth in this field. The research completed by HDIAC highlighted the value of CS-GAG hydrogels on future DoD applications.

References

1. Fraser, J. R., Laurent, T. C., & Laurent, U. B. (1997). Hyaluronan: Its nature, distribution, functions and turnover. Journal of Internal Medicine, 242(1), 27-33. doi:10.1046/j.1365-2796.1997.00170.x
2. Burdick, J. A. & Prestwich, G. D. (2011). Hyaluronic Acid Hydrogels for Biomedical Applications. Adv. Mater. , 23(12). doi:10.1002/adma.201003963
3. Karumbaiah, L., Enam, S. F., Brown, A. C., Saxena, T., Betancur, M. I., Barker, T. H., & Bellamkonda, R. V. (2015). Chondroitin Sulfate Glycosaminoglycan Hydrogels Create Endogenous Niches for Neural Stem Cells. Bioconjugate Chem. 26(12), 2336-2349. doi:10.1021/acs.bioconjchem.5b00397
4. Lash, Marilyn (2015) TBI and PTSD: Navigating the Perfect Storm. Retrieved from http://www.brainlinemilitary.org/content/2013/03/tbi-and-ptsd-navigating-the-perfect-storm_pageall.html (accessed January 26, 2016).
5. Veterans Statistics: PTSD, Depression, TBI, Suicide. (2015, Sept. 20). Veterans and PTSD. Retrieved from http://www.veteransandptsd.com/PTSD-statistics.html (accessed January 26, 2016).
6. Schwarzbold, M. et al. (2008). Neuropsychiatric Disease and Treatment, 4(4): 797-816. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2536546/ (accessed January 26, 2016).
7. DoD Numbers for Traumatic Brain Injury Worldwide – Totals. (2015) Defense and Veterans Brain Injury Center. Retrieved from http://dvbic.dcoe.mil/sites/default/files/Worldwide-Totals-2015.pdf (accessed January 26, 2016).
8. French, Louise M. (2010). Military Traumatic Brain Injury: An Examination of Important Differences. Brainline Military. Retrieved from http://www.brainlinemilitary.org/content/2011/01/military-traumatic-brain-injury-an-examination-of-important-differences_pageall.html (accessed January 26, 2016).
9. Cooper, L. (2015, May 1). Reference Card Helps Identify TBI-related Vision Problems. Retrieved from http://www.health.mil/News/Articles/2015/05/01/Reference-Card-Helps-Identify-TBIrelated-Vision-Problems (accessed January 26, 2016).
10. Military Health System Communication Office. (2014, March 11). Eye Injury Registry Promises to Advance Vision Care. Retrieved from http://www.health.mil/News/Articles/2014/03/11/Eye-Injury-Registry-Promises-to-Advance-Vision-Care (accessed January 26, 2016).
11. Wirostko, B., Mann, B. K., Williams, D. L., & Prestwich, G. D. (2014). Ophthalmic Uses of a Thiol-Modified Hyaluronan-Based Hydrogel. Advances in Wound Care, 3(11), 708-716. doi:10.1089/wound.2014.0572
12. Widjaja, L., Bora, M., Chan, P., Lipik, V., Wong, T., & Venkatraman, S. (2013). Hyaluronic acid-based nanocomposite hydrogels for ocular drug delivery applications. J. Biomed. Mater. Res., 102(9), 3056-3065. doi:10.1002/jbm.a.34976
13. Severe Hearing Impairment Among Military Veterans --- United States, 2010. (2011, July 27). Morbidity and Mortality Weekly Report, 60(28): pgs 955-958. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6028a4.htm (accessed January 26, 2016).
14. Christopherson, Gergory T. and Nesti, Leon J. (2011, October 19). Stem cell applications in military medicine. Stem Cell Research and Therapy, 2(5). Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3308037/ (accessed January 26, 2016).
15. Trophic Factors. (2015). ALS Association. Retrieved from http://www.alsa.org/research/about-als-research/trophic-factors.html?referrer=https://www.google.com/ (accessed January 26, 2016).
16. Patnaik,Padmaja, Amoroso, Paul, Mundt, Ken, Bigelo, Carol. (2000). Disabling Knee Injury in the United States Army: Classification of Injury for Etiological Research. Military Performance Division. U.S. Army Research Institute of Environmental Medicine. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=4&cad=rja&uact=8&ved=0CDYQFjADahUKEwjMnd_C7uDIAhWKRyYKHW0IB-wU&url=http%3A%2F%2Fwww.dtic.mil%2Fcgi-bin%2FGetTRDoc%3FAD%3DADA383861%26Location%3DU2%26doc%3DGetTRDoc.pdf&usg=AFQjCNFELEuJS2Slg1qX-e1mMcRaR2gzQeA (accessed January 26, 2016).
17. Castells-Sala C, Alemany-Ribes M, Fernandez-Muiños T, Recha-Sancho L, Lopez-Chicon P et al. (2013) Current Applications of Tissue Engineering in Biomedicine. J Biochip Tissue chip S2:004. doi: 10.4172/2153-0777.S2-004
18. Burdick, J., & Prestwich, G. (2011). Hyaluronic Acid Hydrogels for Biomedical Applications. Adv. Mater., 23, H41-H56. doi:10.1002/adma.201003963
19. Kim, I., Mauck, R., & Burdick, J. (2011). Hydrogel design for cartilage tissue engineering: A case study with hyaluronic acid. Biomaterials, 32(34), 8771-8782. doi:10.1016/j.biomaterials.2011.08.073


HDIAC's Technical Inqury Services
Have Scientific or Technical questions?
DoD requirements and/or applications?
Literature Reviews?
Knowledge Gap Analysis?
HDIAC offers four free hours of technical inquiry services to help with information and analysis needs.
For more information, or to submit an inquiry, visit www.hdiac.org or call (865) 535-0088

Calendar of Events

March 2016

Agile Biomanufacturing Industry Listening Workshop
AE
3/15/16
Berkeley, CA

Federal Information Systems Security Educators' Association 29th Annual Conference
HD
3/15/16-3/16/16
Gaithersburg, MD

Lab-On-A-Chip & Microfluidics 2016
3/15/16-3/16/16
M
Madrid, Spain

Point-Of-Care Diagnostics
M
3/15/16-3/16/16
Madrid, Spain

2016 Wind Energy Workshop
AE
3/15/16-3/16/16
Lowell, MA

California's Distributed Energy Future 2016
AE
3/16/16
San Francisco, CA

What You Need to Know About OSHA's New Construction Confined Space Standard
3/16/16
Webinar

WINDExchange Webinar: Wind Permitting Toolkit and Model Zoning Ordinance
AE
3/16/16
Webinar

Superbugs & Superdrugs 2016
M
3/16/16-3/17/16
London, UK

2016 ACORE National Renewable Energy Policy Forum
AE
3/16/16-3/17/16
Washington, D.C.

Biomarker Summit 2016
M
3/21/16-3/23/16
San Diego, CA

Maritime Security 2016
HD/CIP
3/21/16-3/23/16
Norfolk, VA

Power Grid Resilience Summit
CIP/HD
3/21/16-3/23/16
Phillidelphia, PA

AWEA Wind Project Siting and Environmental Compliance Conference 2016
AE
3/22/16-3/23/16
Charleston, SC

4th Annual Joint Civil & DoD CBRN Symposium
CBRN
3/22/16-3/23/16
Alexandria, VA

BioPharma Asia Convention
M
3/22/16-3/24/16
Singapore, Korea

2016 Preparedness, Emergency Response and Recovery Consortium
M
3/22/16-3/24/16
Orlando, FL

World Vaccine Congress
M
3/29/16-3/31/16
Washington, D.C.

2016 Virginia Emergency Management Symposium
HD
3/29/16-4/1/16
Newport News, VA

Modernizing the Regulatory System for Biotechnology Products Public Meeting
CIP
3/30/16
Davis, CA

Transmission and Grid Basics for Tribal Economic and Energy Development
AE
3/30/16
Webinar

Biorenewable Deployment Consortium
AE
3/30/16-3/31/16
Charleston, SC

Northewast Biomass Heating Expo 2016
AE
3/30/16-4/1/16
Burlington, VT

Southwest Border Security Week
HD
3/30/16-4/1/16
McAllen, TX

Unmanned Ground Systems Conference
HD
3/30/16-4/1/16
Detroit, MI

April 2016

2016 Critical Infrastructure Symposium
CIP
4/3/16-4/5/16
Charleston, SC

Global Pellet Market Outlook Summit
AE
4/11/16
Charlotte, NC

International Biomass Conference
AE
4/11/16-4/14/16
Charlotte, NC

Border Security Expo 2016
HD
4/13/16-4/14/16
San Antonio, TX

USA Science and Engineering Festival
4/14/16-4/17/16
Washington, D.C.

SPIE Defense + Commerical Sensing 2016 (DCS)
HD/CBRN
4/17/16-4/21/16
Baltimore, MD

2016 Partners in Emergency Preparedness Conference
HD
4/19/16-4/21/16
Tacoma, WA

28th Annual Missouri Emergency Management Conference
HD
4/19/16-4/22/16
Brason, MO

Advanced Energy Conference 2016
AE
4/20/16-4/22/16
New York, NY

2016 Armed Forces Communications and Electronics Association Defensive Cyber Operations Symposium
HD
4/20/16-4/22/16
Washington, D.C.

CS Week 2016
AE
4/25/16-4/29/16
Phoenix, AZ

Hannover Messe
HD
4/25/16-4/29/16
Hannover, Germany

Aircraft Threat Weapons and Effects Training Course
HD/WMD
4/26/16-4/28/16
Hurlburt, FL

ASIS 26th New York City Security COnference and Expo
HD
4/27/16-4/28/16
New York, NY

Respirator Selection & Cartridge Change Out Schedule Workshop
M
4/27/16-4/28/16
Cincinnati, OH

HDIAC Call for Papers

The HDIAC Journal is a quarterly publication, focusing on novel developments and technology in the alternative energy, biometrics, CBRN, critical infrastructure protection, cultural studies, homeland defense and security, medical and weapons of mass destruction fields.

- Articles must be relevant to one of the eight focus areas and relate to Department of Defense applications.
- Articles should be submitted electronically as a Microsoft Word document.
- We require a maximum of 3,000 words.
- All submissions must include graphics or images (300 DPI or higher in JPG or PNG format) to accompany the article. Photo or image credit should be included in the caption.

HDIAC is now accepting abstracts and articles for consideration for the 2016 publications. For more information, contact the Managing Editor at publications@hdiac.org

Publication Schedule

Volume 3; Issue 3
(Publish Sept. 2016)
Abstract deadline:
4/15/16
Article deadline:
5/16/16

·

Volume 3; Issue 4
(Publish Dec. 2016)
Abstract deadline:
7/15/16
Article deadline:
8/15/16

·

Volume 4; Issue 1
(Publish March 2017)
Abstract deadline:
10/16/16
Article deadline:
11/16/16