The Journal of Conventional Weapons Destruction

Volume 24
Issue 1 *The Journal of Conventional Weapons Destruction Issue 24.1* | Article 1

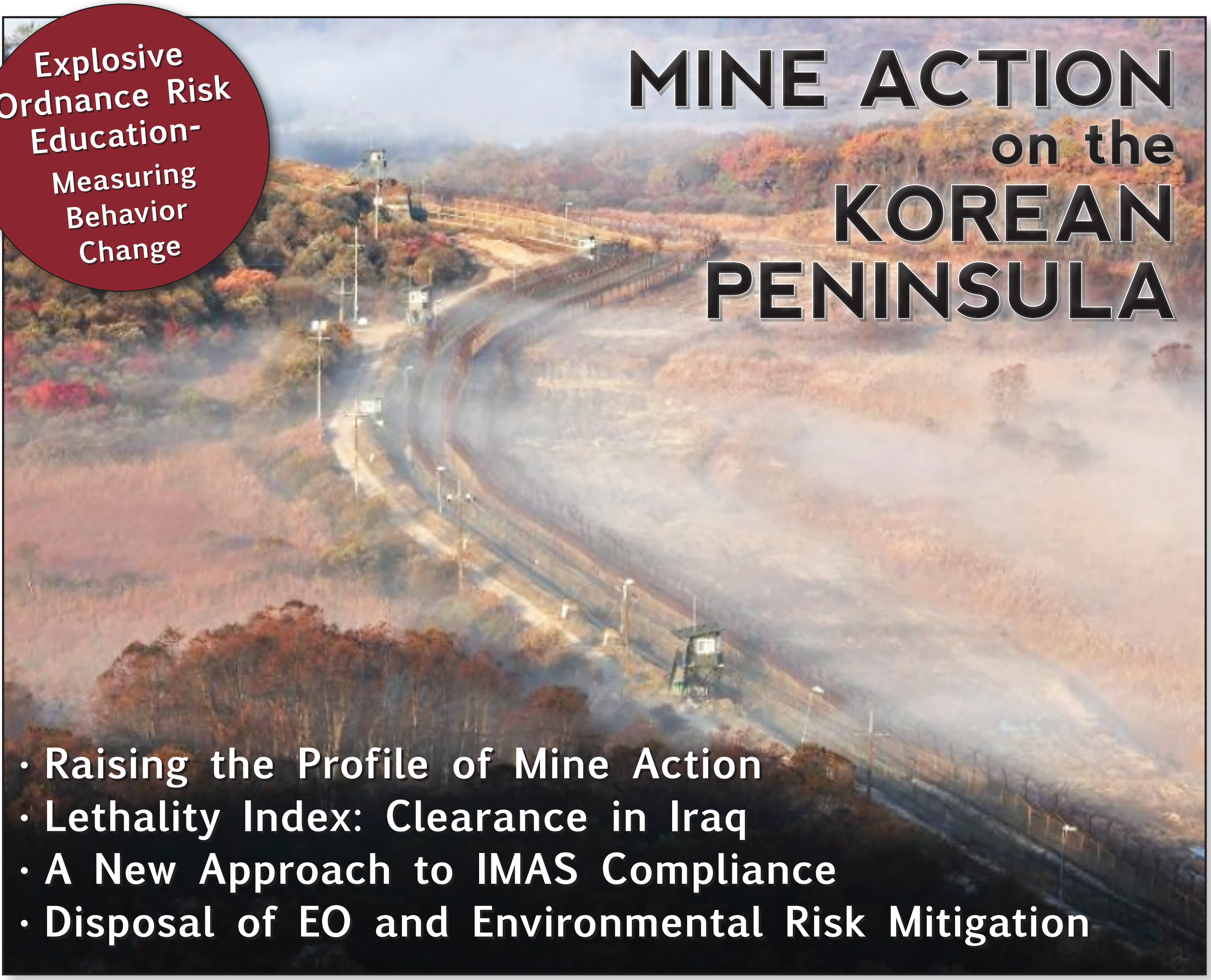
July 2020

The Journal of Conventional Weapons Destruction

CISR JOURNAL

Issue 24.1 | Spring–Summer 2020

THE JOURNAL of Conventional Weapons Destruction



Explosive Ordnance Risk Education- Measuring Behavior Change

MINE ACTION on the KOREAN PENINSULA

- Raising the Profile of Mine Action
- Lethality Index: Clearance in Iraq
- A New Approach to IMAS Compliance
- Disposal of EO and Environmental Risk Mitigation

Contributing Organizations

Binghamton University State University of New York; Phenix Insight Inform . Advise . Assist; GCSP Geneva Centre for Security Policy Where knowledge meets experience; GICHD; The HALO Trust; ICRC; MAG saves lives builds futures; CSRI AME AF of Ukraine; Tetra Tech; UMT; UNMAS; Uppsala Universitet; Waseda University; Norwegian People's Aid

THE JOURNAL of Conventional Weapons Destruction

ON THE WEB: https://issuu.com/cisr-journal or http://www.jmu.edu/cisr/journal/current.shtml

ISSUE 24.1 | SPRING–SUMMER 2020

THE JOURNAL OF CONVENTIONAL WEAPONS DESTRUCTION
Center for International Stabilization & Recovery
James Madison University - MSC 4902
Harrisonburg, VA 22807 / USA
Email: cisr-journal@jmu.edu
http://www.jmu.edu/cisr

ISSUE 24.1 | SUMMER 2020 | ISSN: 2469-7575
- *The Journal of Conventional Weapons Destruction*
  Issue 20.1 ongoing: (print) ISSN 2469-7575 (online) ISSN 2469-7605
- For previous ISSN numbers visit www.jmu.edu/cisr/journal/about.shtml

ON THE COVER
The Demilitarized Zone (DMZ) between North and South Korea.
Photo by Jongwoo Park (National Geographic, 2013).

COMING IN ISSUE 24.2 | FALL 2020

- **Editorial: Empowering Local Capacity in Mine Action**
- **HMA and COVID-19**
- **Balkans**
- **Environmental Concerns of Explosives**
- **HMA and CWD in the Context of IDPs and Migration**
- **Demining in Dense Terrain**
- **Management Information Systems and/or On-Site Analytical Tools**
- **Research and Development**

The Journal of Conventional Weapons Destruction is a professional trade journal for the CWD community, including but not limited to humanitarian mine action, physical security and stockpile management, small arms and light weapons, and other related topics. It is a forum for best practices and methodologies, strategic planning, risk education, and survivor assistance.

The Journal Editorial Board reviews all articles for content and readability, and reserves the right to edit accepted articles for readability and space, and to reject articles at will.

Authors who submit articles to *The Journal* are expected to do so in good faith and are solely responsible for the content therein, including the accuracy of all information and correct attribution for quotations and citations.

This publication is funded [in part] by grants from the United States Department of State. The opinions, findings, and conclusions stated herein are those of the author[s] and do not necessarily reflect those of the United States Department of State, the United States Department of Defense, James Madison University, or the Center for International Stabilization and Recovery.

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To help save natural resources and protect our environment, this edition of *The Journal of Conventional Weapons Destruction* was printed on 30-percent post-consumer waste recycled paper using vegetable-based inks.

A NOTE FROM INTERIM DIRECTOR SUZANNE FIEDERLEIN, PH.D.

We are living in uncertain times as we face an unprecedented global health crisis. In keeping with the tradition of adaptation and creativity in the mine action community, numerous national clearance programs and implementing partner organizations have adjusted operations in order to continue survey, clearance, and risk education work in line with required COVID-19 restrictions. As some places begin to resume a greater range of activity, we recognize the threat presented by this new virus remains pronounced, and we wish all of you safety in your daily lives and good health.

The unprecedented challenges we have all faced these past four months coincided with the start of my new role as CISR interim director. As part of the JMU community, we all transitioned successfully to working remotely and continue to do so as we reach mid-year. Fortunately, my experienced Journal production team continued its work to assemble another remarkable issue to share with you, finding the editorial process actually easier as authors remained closer to their computers and quicker to turn around article versions as they went through the review process. We shall see what the remainder of 2020 has in store for us, as the United States not only continues to grapple with the pandemic but also a long-overdue reckoning with deeply ingrained systemic racial injustices. We at CISR remain committed to our service to the global HMA community, as we also work alongside members of our JMU and local community in these challenging times.

Our spring/summer issue focuses on a variety of topics including the role of the media in HMA, robotics and remote sensing, environmental risk mitigation in mine action, a new approach to accessing and complying with IMAS, as well as developing sustainable national training capacities and explosive ordnance risk education (EORE) activities. We would normally highlight each of our contributors and their articles; however, we have such a full spring/summer edition that in an attempt to save space, I encourage you to review our table of contents for a full listing of this issue's featured articles.

In looking toward our fall issue of *The Journal*, we want to hear from you and your organization on how the HMA sector is coping with COVID-19. How have organizations responded to the pandemic and in what ways have they adapted their operations both in and out of the field? In what ways have organizations leveraged their in-country assets to assist regional authorities and local communities? What does the future look like for HMA operations, what challenges has the sector faced during the past few months, and how as a community can we better adapt to these new circumstances? We look forward to hearing from you.

For more information, please see *The Journal's* Calls for Papers at https://www.jmu.edu/cisr/journal/cfps.shtml.

Suzanne

IN THIS ISSUE:

3 From the Interim Director

4 EDITORIAL: Whither HMA Policy? Linking HMA and Development Assistance
by Lewis Rasmussen, Ph.D. [Tetra Tech]

9 Confidence-Building through Mine Action on the Korean Peninsula
by Guy Rhodes, Ph.D. [Geneva Centre for Security Policy]

18 Disposal of Explosive Ordnance and Environmental Risk Mitigation: Time for Humanitarian Mine Action to Catch Up?
By Roly Evans [GICHD] and Andy Duncan

23 Measuring Behavior Change Resulting from EORE and the Need for Complementary Risk Reduction Activities
By Helaine Boyd [HALO], Sebastian Kasack [MAG], and Noe Falk Nielsen [NPA]

30 Detonating the Media – Raising the Profile of Mine Action
by Paul McCann [The HALO Trust]

35 A New Approach to Understanding, Achieving, and Demonstrating IMAS Compliance
By David Hewitson [Fenix Insight Ltd.]

38 The Lethality Index: Re-Conceptualizing IED Clearance Planning and Delivery in Iraq
By Mark Wilkinson, Ph.D. [UNMAS]

45 Seventh Mine Action Technology Workshop: A Space for Innovation
By Arsen Khanyan and Inna Cruz [GICHD]

48 Understanding the Logic of Rebel Restraint on Landmine Use
By Henrique Garbino [Uppsala University]

53 Developing a Sustainable National Training Capacity: Non-Technical Survey Training in Colombia
By Marc Bonnet, Helen Gray, and Giulia Matassa [GICHD]

56 Automated UAS Aeromagnetic Surveys to Detect MBRL Unexploded Ordnance
By Alex Nikulin*, Ph.D., Timothy S. de Smet*, Ph.D., Andrii Puliaiev**, Vasyl Zhurakhov***, Sofia Fasullo*, Gabriel Chen*, Isaac Spiegel*, and Kaylee Cappuccio*
*[Binghamton University - The State University of New York], **[Ukrainian Multirotor Technologies], ***[State Science Research Institute of Armament and Military Technology Testing and Certification]

63 To What Extent Could the Development of an Airborne Thermal Imaging Detection System Contribute to Enhance Detection?
By Martin Jebens*, Hideyuki Sawada**, Ph.D., Junjie Shen**, and Erik Tollefsen*
*[ICRC] and **[Waseda University]

68 Endnotes

WHITHER HMA POLICY? LINKING HMA AND DEVELOPMENT ASSISTANCE

By Lewis Rasmussen, Ph.D. [Tetra Tech]

Supporting the U.S. Department of State remove explosive hazards from a public fuel depot near Mosul, Iraq, which helped restore transportation operations critical to agricultural activity.
Photo courtesy of Tetra Tech project photo.

In 1999, the International Campaign to Ban Landmines issued a seminal report entitled *Landmine Monitor: Toward a Mine-Free World*. How prophetic they were on the one hand, and how unbridled and unrealistic the Campaign was on the other. Fresh off the 1997 *Anti-Personnel Mine Ban Convention* (APMBC), the report notes a U.S. State Department 1998 declaration that removal had surpassed planting, and "it appears that we have turned the tide in the battle against mines, and that it is possible to solve the AP [anti-personnel] mine crisis in years not decades."[1] The report, stating that the past decade has focused on the threat to innocent civilians, heralds the emergence of a development assistance oriented approach toward demining, known as humanitarian mine action (HMA),[2] which is

> *an integrated approach to removing landmines from the ground and reducing their disastrous impact on mine-affected communities. Nobody knows how many mines there are in the ground, and that number is not very relevant, despite the attention given to the issue. What is relevant is how many people are affected by the presence of mines, which are obstacles to post-conflict reconstruction and socio-economic re-development.*[3]

The campaign's enthusiasm around rapid resolution of the problem was not misguided; after all, parties to the APMBC agreed to clear their contaminated territory within ten years. Two decades later, however, the international community continues to set new clearance timeframes while providing continued assistance.

Around the time of the initial 1999 *Landmine Monitor* report, the UN held the Millennium Summit in 2000 where member nations adopted an agreement known as the Millennium Declaration, which set forth goals and principles geared toward ending underdevelopment and abject poverty, and promoting peace and security. From this agreement, eight broad goals were issued around social-, economic-, and health-based objectives known as the Millennium Development Goals (MDGs). The goals covered poverty, education, gender equality, child mortality, maternal health, disease, the environment, and global partnership, and established twenty-one specific development targets along with sixty indicators to be achieved by 2015.[4] Some states met some objectives, a few achieved many, while many states achieved few, if any, objectives.

The 2015 UN Summit was devoted to the next round of development goals, and the international community discussed the range of challenges and impediments toward lasting development, security, and stability faced by so many countries. The summit also celebrated successes, as broadly measured by quality-of-life gains like positive changes in poverty (those living above the $1.25 per day standard), access to clean water, literacy improvements, and gender parity in primary education.[5] Understanding better the success and shortfalls of the MDG process (2000–2015) was critical, and the insight gleaned was valuable for understanding how to meet the new development goals set for 2015–2030, known as the Sustainable Development Goals (SDGs).

Unfortunately, the relationships between mines and development were not addressed by policy and programming surrounding the 2000 MDGs, nor during the 1997 establishment of the International Mine Action Standards (IMAS) and the United Nations Mine Action Service (UNMAS). Moreover, while some policy writing around the last millennium did explore the issue, the SDGs of 2015 still did not address landmines and demining as intermediate variables along the pathway to development. This lack of connectivity will be addressed further, but for now, **the point is that establishing a relationship between HMA and global development goals was not done well previously, and doing so now is critical for the future of HMA.**

THE FUNDING DOMAIN

At a macro level, globalism currently competes with an inward-looking nationalistic populism that is pressing for reduced levels of foreign assistance while demanding greater accountability for any overseas investments based on "national interest." The argument at hand is driven by concern over value for money, return on investment, and a sustainable, demonstrable impact. Fiscal responsibility is thus the clarion call to which both the global assistance and HMA communities must answer—and with clear substantiation, as both are often considered foreign policy tools.[6]

Donors contribute for varying reasons, depending on amount, cause, beneficiaries, recipients, and timing. While motives may range from altruism to legislative mandate (i.e., the United Kingdom), to unabashed self-interest, countries nonetheless expect a return on their humanitarian assistance—whether it be increased stability, enhanced self-sufficiency, improved relationships, future market access for the donor's private sector, or all of the above. Regardless of political ideology, the use of public revenue to support socioeconomic needs in other countries is receiving more scrutiny, along with more consistent and wider expectations for demonstrable results, benefitting both recipient and donor. Additionally, further challenges may yet arise as the vast amount of donor support is concentrated quite narrowly—both in terms of the percentage of support offered by a handful of donors as well as the majority of assistance being provided to just a handful of recipient countries.

According to the 2019 *Landmine and Cluster Munition Monitor*, the three largest mine action donors from 2014 to 2018 (United States, European Union, and Japan) account for nearly 58 percent of all funding. The top seven donors (adding the United Kingdom, Germany, Norway, and the Netherlands) accounted for $2.147 billion of the $2.629 billion in total assistance.

Also according to the 2019 *Landmine Monitor,* the level of US funding alone over this time frame, $947.1 million, accounted for 36 percent of total global funding.[7] However, the US 2017 HMA funding of $320.6 million was more than double the US 2016 HMA contribution of $152.4 million. Additionally, more than half of the 2017 funds ($169.35 million) went to projects in Iraq and Syria alone.[8] In comparison, these two countries received $17 million more than the total US 2016 contribution, and of that $152.4 million, $106.55 million went to Iraq.[9]

Fortunately, US funding has remained strong for years, with consistent bipartisan congressional and presidential support. Despite recent annual averages of roughly $200 million from the United States alone, resources fall short compared to need. Overall, while there are approximately sixty contaminated countries, six countries alone received nearly 52 percent ($1.361 billion) of the total 2014–2018 funding for mine action assistance.[10]

With these challenges in mind, a brief look at global development assistance funding is warranted. As noted in the Organisation for Economic Co-operation and Development (OECD) in Table 1, total net resource flows for global development assistance steadily decreased in terms of the percentage of cumulative donor Gross National Income (GNI) from 2010 to 2017, with the exception of 2014. Fortunately, the actual dollar amounts of development assistance remained relatively steady, with upticks in 2016 and 2017.

In 2018, overseas official development assistance was $149.3 billion, though "foreign direct investment to developing countries dropped by around a third from 2016 to 2017, following a 12 percent drop in overall external finance from 2013 to 2016."[11] Additionally, recent assistance levels were weakened by the significant sums spent on Middle East refugee and internally displaced persons (IDP) costs—for example, the level of donor assistance expenditures focused on refugee costs alone increased in 2016 by 27.5 percent to $15.4 billion from 2015 costs.[12]

These financial snapshots suggests several takeaways for the HMA community: (1) overarching development assistance is somewhat unstable, (2) enormous sums, comparatively, flow through development assistance streams, and (3) critical issue areas for Official Development Assistance (ODA) policy include considerations highly connected to HMA—namely, humanitarian assistance funding, cost of displaced persons, and direct foreign investment and other private funding.

Children in a Central Africa Republic community that Tetra Tech was assisting under a USAID illegal mining and conflict diamonds project.
Photo courtesy of Tetra Tech.

Most critical, however, is the need to recognize that the HMA community has an important opportunity to better align with, and integrate into, global development assistance objectives. Integration is imperative at this time when many donor countries face internal sociopolitical pressures to focus public spending internally and to better substantiate returns on their investments made abroad. Two of the biggest HMA donors, the United States and the United Kingdom, for example, are each mired in political consternation about reducing foreign assistance spending and reorganizing their national foreign assistance institutions and mandates. While global funding for HMA was at an all-time high in 2017 and 2018,[13] increased donor fatigue toward HMA and development assistance is a real possibility (particularly should donor assistance disproportionately shift toward global health requirements, and even more so should a global recession emerge as a result of COVID-19), as is the uncertainty associated with changing foreign policy and national security priorities related to assisting conflict-affected countries, peacekeeping missions, and the larger Overseas Contingency Operations (to use a US term). With increased competition for potentially diminishing funds, **strengthening the synergistic HMA-development relationship may help both communities achieve more with less.**

FLIPPING THE SCRIPT: CHANGING THE ETHOS FROM CASUALTY REDUCTION TO SUPPORTING DEVELOPMENT OUTCOMES

Much HMA progress over the past two decades has come from a dedicated and consistent higher-order message that was the cornerstone of the initial campaign: *mine action saves innocent lives*.[14] That said, however, the horrors of chronic underdevelopment far eclipse damage caused by mines and munitions when measured in deaths and victims.

The 2019 *Landmine and Cluster Munition Monitor* reported 149 square kilometers cleared worldwide in 2016,[15] when global victims totaled 9,439 (the second highest total in over twenty years),[16] including approximately 2,100 deaths.[17] Typical estimates are that over 80 percent of mine victims are civilian and almost half are children—in many instances because they are working in fields or picking up scrap metal to help earn family income. In contrast, an analysis of global health data indicate that an "innocent victimization" milieu around children in the developing world in 2016 was considerably worse:

- One in twelve children under the age of five in sub-Saharan Africa died, and one in twenty-two died in South Asia; the North American ratio was 1:152 and the European ratio was 1:204.
- 2.78 million children under the age of five in sub-Saharan Africa died, along with another 1.73 million children in South Asia. This contrasts with 28,000 North American deaths and 43,000 in Europe.[19]
- Deaths among children aged five to fourteen in sub-Saharan Africa totaled 513, 000, 241,000 in Southern Asia, 10,000 in Europe, and 6,000 in North America.[20]
- 407,000 people died from malaria in Africa alone.[21]
- 525,000 children died from diarrhoeal diseases, with over 1,400 deaths per day.[22]
- 1.4 million children under the age of five died from acute lower respiratory infection, more than 95 percent of whom were from low and middle income countries.[23]

The main point of these examples is not to suggest the horror and outrage associated with munitions contaminants should lessen, but rather the emphasis on how mines/munitions preclude development outcomes should concurrently sharpen. For instance, **all** of the above mortality categories are considered preventable—**if** the levels of national development were improved.[24] Perhaps the policy orientation of HMA needs to include the alignment between mine action and the SDGs, and toward the contributory impact mine action success or failure has on social, political, and economic well-being.

	2010	2011	2012	2013	2014	2015	2016	2017
Total Official Development Assistance and Private Flows*	512,792	504,701	477,702	450,382	587,731	315,651	317,435	422,968
Only Official Development Assistance **	128,484	135,111	127,030	134,847	137,539	131,563	144,921	147,160
Total Flows as % of GNI	1.25	1.14	1.07	0.99	1.26	0.72	0.71	.89

* This includes bilateral and multilateral institutional assistance, along with other official public investment, as well as all private direct investment and private grants.
** Only governmental bilateral and multilateral institutional assistance is included.
Table 1. OECD Global Development Assistance Trendline (in millions).
Figure courtesy of OECD International Development Statistics, Volume 2018 Issue 1.

With support from the U.S. Department of State and other donors, the Lao People's Democratic Republic has linked UXO removal to its National Development plan, where female demining teams play an important role in UXO Lao's efforts to clear land for economic development. *Photo courtesy of Tetra Tech project photo.*

Although the *sine qua non* role of mine action in post-conflict reconstruction and stabilization countries is generally understood, undertaking more specific causal pathway mapping exercises does not seem widespread. Much like modelling used to measure the impact of donor and foreign direct investment on post-war reconstruction to help guide economic growth, algorithmic models could highlight the potential impact of appropriate, timely, and sufficient HMA on development objectives and the corresponding impact on resulting economic growth forecasting. Likewise, and conversely, models should run the potential impact of insufficient or non-existent munitions response. [25]

This should not be an overly onerous task, given a twenty-plus year applied policy and programming research base from the Geneva International Centre for Humanitarian Demining (GICHD, established in 1998), *The Journal of Conventional Weapons Destruction,* and the Peace Research Institute Oslo's (PRIO) project: *Assistance to Mine-Affected Communities*, which ran from 1999–2009. The United Nations Development Program (UNDP) also works closely with the GICHD and PRIO (and others), co-sponsoring events and research, and the UN Inter-Agency Coordination Group on Mine Action (IACG-MA) has long had between twelve and fourteen members whose mandates include some aspect of mine action as well as development assistance.

In spite of some efforts to create bridgeheads on each side, the spans connecting HMA and development assistance communities have not been adequately built. For example, no references to economic growth and development were made in the original 1999 Maputo Declaration nor in the ensuing 2014 Review Conference. Similarly, the 2016 *Convention on Cluster Munitions* had just one reference to victim assistance and development. Neither demining nor HMA were associated with the 2000 MDG efforts, or, more sadly, in the literature and conversations surrounding the 2015 SDGs, including the UN publication *Transforming our World: The 2030 Agenda for Sustainable Development*).[26]

Perhaps more important, however, IMAS Series 14 (*Evaluation of Mine Action Programmes* 14.10 and 14.20) makes scarce reference to development.[27] Neither document even raises the idea of exploring measurable connections between HMA activities and development outcomes and impacts. Although Series 14 is overdue for an update (all IMAS publications are *scheduled* for updates every three years), **it is possible that the task and imperative before us will be better served by a new IMAS series focused on aligning and measuring the relationship between mine action and development. At the very least, an IMAS 14.30 should be considered.**

Most important though, the November 2019 Oslo Review Conference does make clear that mine action is a "key enabler for development, humanitarian action, peace and security"[28] and that the corresponding Action Plan for 2020-2024 includes focal points for HMA to further the achievement of the SDGs. The time is indeed right for HMA to evolve as a significant component of this development/security equation—one more widely and publicly seen and understood, and one better articulated in terms of evidence-based input, with HMA becoming an intervening variable contributing toward a larger series of ends, namely the SDGs. This evolution will require demonstrating return on investment in terms of both the technical aspects of HMA, e.g., monitoring and evaluating current key performance indicators (KPIs),[29] and on a new set of impact analytics that measure how HMA serves as an intervening variable on a range of development objectives and outcomes.

INCREASING THE *BANG FOR THE BUCK*: DEMONSTRATING VALUE, SUBSTANTIATING RETURN ON INVESTMENT

HMA donor support has tended to be tied more toward a given foreign policy or national security platform rather than a development assistance agenda. The United States, for example, has provided more than $3.7 billion dollars of total conventional weapons destruction assistance to over 100 countries from 1993–2019, making the United States the single largest donor by far. However, just under $1.6 billion was spent on only five countries (Iraq, Afghanistan, Laos, Cambodia, and Vietnam).[30] This pattern of linking mine assistance to national security and foreign policy is consistent with other large donors. The point is this approach will have to change if HMA is to play a significant contributory role in achieving the global SDGs. A wider country distribution pattern is one approach; however, integrating HMA more widely into development assistance policy and programming ought to enable more countries to provide more support to HMA efforts.

Similarly, development assistance is increasingly becoming more of a foreign policy and/or national security tool. In terms of additional similarities, the intent of both HMA support and development assistance is to lessen suffering, fear, risk, and both physical and economic insecurity, and to improve human and community well-being. Also, the performance and impact of both communities should be held accountable.[31] Although both communities ought to be exploring their relationship more explicitly, perhaps the onus falls on the HMA community to better demonstrate its value to development assistance.

If mine action is to receive the support needed to accomplish the larger HMA mission, it will likely need to adopt a value-for-money orientation, defining and operationalizing a performance-based management approach toward development outcomes. The sector must be able to both articulate and substantiate evidenced-based policy, programming, and budgeting capabilities and results. Demonstrating value is particularly important as Stanley Brown (U.S. Deputy Assistant Secretary of State) recently noted, the "global need for HMA programs continues to outstrip available resources."[32] Moreover, in the post-COVID-19 economy, resources for both HMA and development assistance writ large may be further challenged.

Although the HMA community will likely be better served by taking the initiative, defining, tracking, and reporting on development and outcome-based KPIs will require cooperation and collaboration with the development assistance community. Ideally, both communities will be able to articulate how the presence or absence of HMA affects development goals from the immediate to the long-term (including the policy and programming distinctions between humanitarian assistance and longer-term development). Noting that we are already one-third through the fifteen-year SDG performance period, such an outcome will require immediate action on the part of both communities to increase dialogue in earnest, to better and more fully frame and initiate operational research agendas, to pilot targeted programs, and to develop and execute a monitoring, evaluation, and learning regiment focused on HMA-SDG relationships.

This process will require widespread recognition of the need for policy, programming, and budget evolution/maturation associated with mainstreaming HMA into development assistance (see endnote 25). The joint GICHD and UNDP report "Leaving No One Behind" provides a solid foundation on which to build, as does the 2019 Oslo Review Conference report.[33] Illustrative areas where over a half century of relevant development assistance expertise can be applied to existing HMA include:

- Assistance with improving assessments, monitoring, evaluation, and learning (to include knowledge and data management systems)
- Enhancing sustainable land management and use—including strong return on investment estimating to prioritize actions (including a focus on critical infrastructure and resumption of economic activity)
- Institutional strengthening of national mine action authorities—including improving transparency and accountability, and management/leadership capabilities
- Helping national authorities develop a whole-of-government orientation, working more effectively with other national ministries, including integrating HMA into national development plans[34]
- Assisting contaminated countries with preparedness and resiliency related to environmental and climate-oriented changes that might increase explosive ordnance hazards
- Helping define and promote public-private partnerships

The HMA and development assistance relationship should have different degrees of connectivity or alignment in different circumstances, as Gasser noted.[35] There are instances where

1. **No formal** linkage can or should be made, such as when political and/or security considerations supersede development efforts.
2. **Coordination** should be the objective when development priorities focus on jobs and anti-poverty objectives while the political-military imperatives are weapons removal and abatement and clearing ground.
3. **HMA leads** and is an enabler of development assistance when munitions prioritization takes precedent and development activities require clearance a priori before they can begin.
4. **Active integrated planning and execution** is prioritized, and HMA efforts and objectives are viewed as part of an overall development strategy—in other words, mine action impact is a formal part of a development impact assessment such that a low-priority mine action area might be cleared first to help accomplish development objectives.

In the end, if actionable correlations between HMA and the SDGs can be framed, supported, and communicated, the value for money argument becomes easier in terms of attracting resources from both public and private sources, including increased direct foreign investment.[36] This alignment and integration of HMA and development will not only enable more effective and efficient targeting of whatever resources are available, but will also improve investment risk mitigation, which may in turn generate more sustainable post-clearance investments. As HMA activities are better framed as *enablers and catalysts for development* as opposed to separate *precursors to development*, the value for money argument is strengthened, further justifying sustained mine action expenditures.

See endnotes page 68

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CONFIDENCE-BUILDING THROUGH MINE ACTION ON THE KOREAN PENINSULA

By Guy Rhodes, Ph.D. [Geneva Centre for Security Policy]

Handshake between North and South Korean Military at the DMZ, October 2018.
Image courtesy of MND Archives.

The Korean Peninsula is divided by a strip of land, the Demilitarized Zone (DMZ), which represents the de facto border between the Democratic People's Republic of Korea (DPRK), more commonly known as North Korea, and the Republic of Korea (ROK), or South Korea. Contrary to its name, the DMZ is the most militarized zone on earth, and it delineates a stand-off between militaries composed of several million professional and reservist soldiers on both sides. It is the "Cold War's last divide"[1] and one of the most symbolic barriers between two nations. It is also heavily mined with both anti-personnel and anti-vehicle landmines, and contaminated with unexploded ordnance (UXO) from extensive ground battles and heavy aerial bombardment.

This article explores the nature and extent of explosive ordnance contamination and the physical environment within the DMZ. It considers recent changes in the political landscape that have allowed unprecedented developments within the DMZ to take place—including coordinated demining operations between military forces of North and South Korea, as well as the beginning of a human remains recovery program.

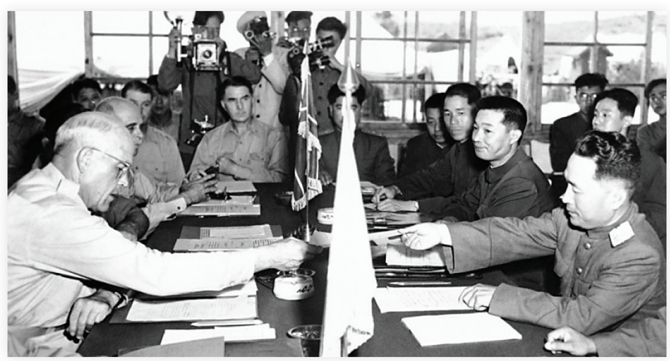
Joint demining operations are currently suspended and the political situation remains complex, but mines do not go away. The opportunity that mine action offers to contribute to confidence building on the Korean Peninsula is without parallel; such potential is explored here.

In this context and notwithstanding the considerable expertise, resources, and perspectives of the two Koreas and that of the US-led United Nations Command (UNC),[2] this article suggests a vision for the architecture of mine action on the peninsula. This includes thoughts on further developing the legal and institutional frameworks for the sector and the potential role that the international community may offer in contributing to peace dividends, both by its presence, and its experience gained elsewhere in the world that may have application in Korea.

HISTORY OF THE KOREAN WAR AND THE ARMISTICE AGREEMENT

In the English-speaking world, the Korean War has been called "The Forgotten War," as its memory is often overshadowed by World War II and the Vietnam War. It was, however, one of the most devastating conflicts of the modern era. It incurred the destruction of virtually all of Korea's major cities and resulted in approximately 3 million war fatalities with a larger proportional civilian death toll than either World War II or the Vietnam War.[3]

The conflict was between North Korea (with the support of China and the Soviet Union) and South Korea (with the support of the UNC, principally the United States but with combat troops from sixteen additional states under a UN Flag). It began on 25 June 1950 and ended on 27 July 1953 when the UNC and the Chinese-North Korean Command signed the Korean Armistice Agreement.



Signing of the 1953 Korean Armistice Agreement.
Photo courtesy of File/AP.

The armistice established the Military Demarcation Line (MDL) and the DMZ, a 4 km wide and 250 km long fortified buffer zone between the two Korean nations. After the agreement, a withdrawal of forces and the rapid establishment of the DMZ left thousands of human remains within its boundaries, which are only now being recovered. The armistice remains only a cease-fire arrangement between military forces rather than an agreement between governments to normalize relations. No formal peace treaty has been signed, and the two nations technically remain at war.

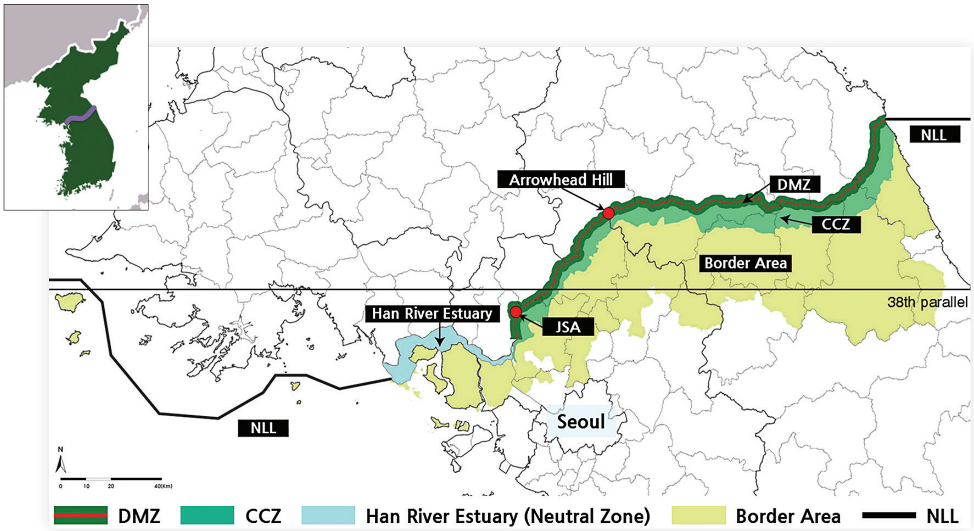


Figure 1. Map of the central portion of the Korean Peninsula showing the DMZ and surrounding border areas.
Figure courtesy of Park Eun-Jin et al, 2012.

BORDER AREA ZONING

The DMZ and surrounding border areas to the south are divided into three zones: the DMZ itself, the Civilian Control Zone (CCZ), and the Border Area (Figure 1). The DMZ is split 2 km north and 2 km south of the MDL, with half of the DMZ located in the ROK and half in the DPRK. The outer limits of the DMZ are termed the Northern Limit Line (NLL) and Southern Limit Line (SLL). This area was established to safeguard against incidents that may provoke hostilities,[4] and in accordance with the armistice, the jurisdiction for the southern portion of the DMZ falls under the responsibility of the US-led UNC.[5] Conversely, the jurisdiction of the CCZ rests with the ROK Army, and the Border Area under that of the local governments.

EXTENT AND NATURE OF THE EXPLOSIVE ORDNANCE CONTAMINATION

Landmines and UXO are present in all three zones of jurisdiction on the ROK side of the border: the DMZ, the CCZ, and the northern parts of the Border Area. They are also present around some military installations and bases elsewhere on the southern portion of the peninsula.

Mined areas in the DMZ, and to some extent the CCZ, are not as defined as one might expect. While many minefields have records, mines have also been air-delivered and laid hastily, creating uncertainty in several areas. In addition, variation in statistics may also be reflective of failures in knowledge management practices over the past sixty-seven years. Much of the contamination is ageing, although there have been periods of mine replenishment and reinforcement during periods of heightened tension—such as during the Cuban Missile Crisis (1962) and the buildup to the Seoul Olympics (1988).

Contamination originating from ground battles and aerial bombardment such as grenades, artillery shells, and mortars is widespread but less well defined. It is present on the surface of the ground and at shallow depths, and in the case of air-delivered bombs, often at considerable depth.

Table 1 details contamination known in the DMZ and CCZ as reported by the ROK Joint Chiefs of Staff. The exact number could be appreciably more, with some sources quoting between 1 and 1.2 million mines in total on the south side. Far less is known about the mine-laying strategies and quantities of mines deployed by North Korean forces. The numbers of mines are reported to be at least as many as those to the south of the MDL, with some sources suggesting numbers may be twice as high.[6]

THE CHANGING POLITICAL CONTEXT ON THE KOREAN PENINSULA, 2018–2020

Signing of the CMA by ROK and DPRK Ministers of Defense, September 2018.
Image courtesy of Pyeongyang Press Corps.

Although the political situation has become more complex on the peninsula since the Hanoi Summit between the United States and North Korea in February 2019, the developments that occurred in 2018 were ground breaking. On 27 April 2018, the two Koreas held a summit between South Korea's President Moon Jae-in and North Korea's Chairman Kim Jong Un. This meeting resulted in the two leaders signing the Panmunjom Declaration on Peace, Prosperity and Reunification of the Korean Peninsula.

The Panmunjom Declaration led to other bilateral declarations and summits involving South Korea, North Korea, and the United States. On 19 September 2018, the respective Ministers of Defense for North and South Korea signed an unprecedented Comprehensive Military Agreement (CMA).

	Total	Controlled Protection Zones		Restricted Protection Zones of Border Areas	Rear Areas
		DMZ	CCZ		
Sites	1,308	786 (15 undocumented)	433 (276 undocumented)	22	67
Mines	828,000	380,000	389,000	50,000	9,000

Table 1. Status of confirmed hazardous areas (CHA) in South Korea.
Table courtesy of Republic of Korea Joint Chiefs of Staff (ROK JCS).

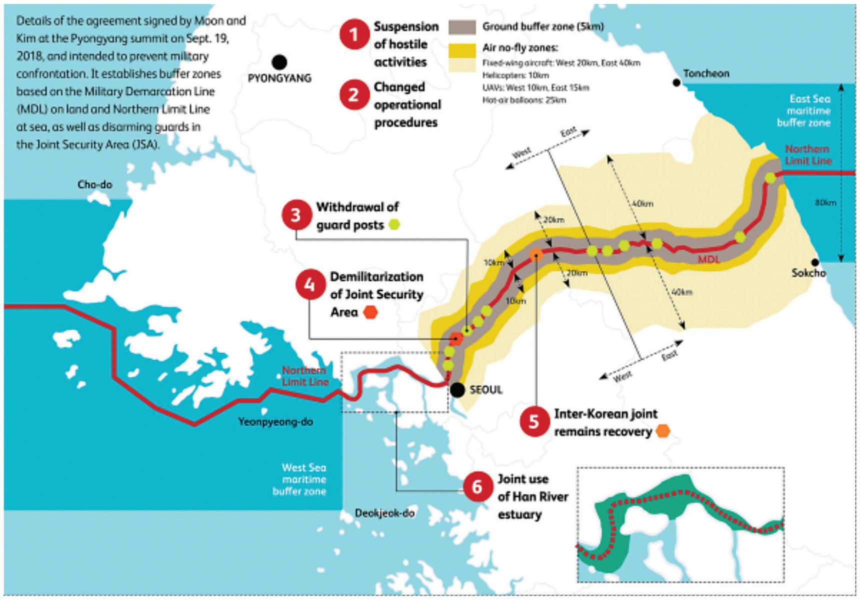


Figure 2. Key elements of the Comprehensive Military Agreement.
Figure courtesy of an illustration in Global Asia Vol 14, no. 2, June 2019.

The CMA focused on five areas: (1) suspension of hostile activities, (2) military measures to transform the DMZ into a peace zone, (3) establishment of a marine peace zone, (4) military communication and exchange, and (5) measures to promote military confidence building.

Of particular interest for this article are the two annexes to the CMA concerning demining operations at the Joint Security Area (JSA) at Panmunjom, and at the former battle ground at Arrowhead Hill. These annexes set the scene for collaborative demining operations between the ROK, DPRK, and the UNC that began on 1 October 2018—a joint activity that was unimaginable twelve months before. While engagement occurred for a period, subsequent strained relations led to an effective freeze in confidence-building initiatives, and joint operations did not resume in 2019. This remains the status quo as of June 2020; however, mines do not disappear, and the political environment can change quickly. For the time being, ROK Army demining units, supported by the UNC continue to work unilaterally, but mine action will continue to offer considerable opportunities and powerful optics for confidence building between the DPRK and ROK when conditions again become conducive.

DEMINING OPERATIONS IN THE DMZ

Location	Year	Area	Mines Removed
CCZ	2006–2017	14 sites	1,443
Southern CCL/ Border Areas	2005–2017	42 sites	5,405
Rear Areas	1998–2017	76 sites	58,872
Total		132	65,720

Table 2. Mine clearance status to 2017 from ROK military operations.
Table courtesy of Republic of Korea Joint Chiefs of Staff (ROK JCS).

Demining operations in South Korea before 2018 were largely restricted to areas away from the DMZ. Table 2 illustrates the clearance statistics from 1998–2017. A total of 65,720 mines were cleared from the CCZ, southern edge of the Civilian Control Line (CCL), and particularly from sites around military bases and installations in the Rear Areas across the ROK.

Since 2018 and under the auspices of the CMA, clearance activities within the DMZ itself have been undertaken at the JSA at Panmunjom and at the formal battle site at Arrowhead Hill.

Demining at the Joint Security Area (Figure 2 Label 4). The Panmunjom JSA is the only portion of the DMZ where North and South Korean forces stand face-to-face. The JSA is used for diplomatic engagements.

Deminers from the 127 ROK Army Engineering Battalion, supported by the UNC, conducted operations within the southern portion of the JSA (shaded blue in Figure 3). The U.S. Army Corps of Engineers and representation from the U.S. Department of State acted as observers. In northern zones (shaded yellow), the Korean People's Army (KPA) conducted its own independent clearance operations.[7] At times, ROK-UNC teams were in proximity to DPRK teams and exchanged cordial greetings and conversations. Both sides focused on areas of suspected mine and UXO contamination with the intent to further demilitarize the JSA and support greater tourist circulation. The operations are now complete on the south side and declared complete on the north.

First tri-lateral negotiations on the implementation of the CMA, 16 October 2018.
Image courtesy of UNC Archives.

Operations of the ROK Army in the southern sectors between 1 and 19 October cleared 36,461 sq m of land and recovered considerable quantities of metal debris, but no mines were present. To the north, the KPA were observed conducting demining operations at three localities between 1 and 18 October. The KPA appeared to use detectors, primitive probes, and pitch-fork-style tools within operations that claimed the removal and destruction of 636 mines.[8]

An underlying challenge during the JSA clearance task was the lack of common standards for operations, particularly in quality management procedures for released land. Both the ROK Army and the DPRK KPA used different military doctrines for demining, and there was a disparity in demining resources and equipment. In the longer term, the UNC suggests that joint mine action operations would benefit from

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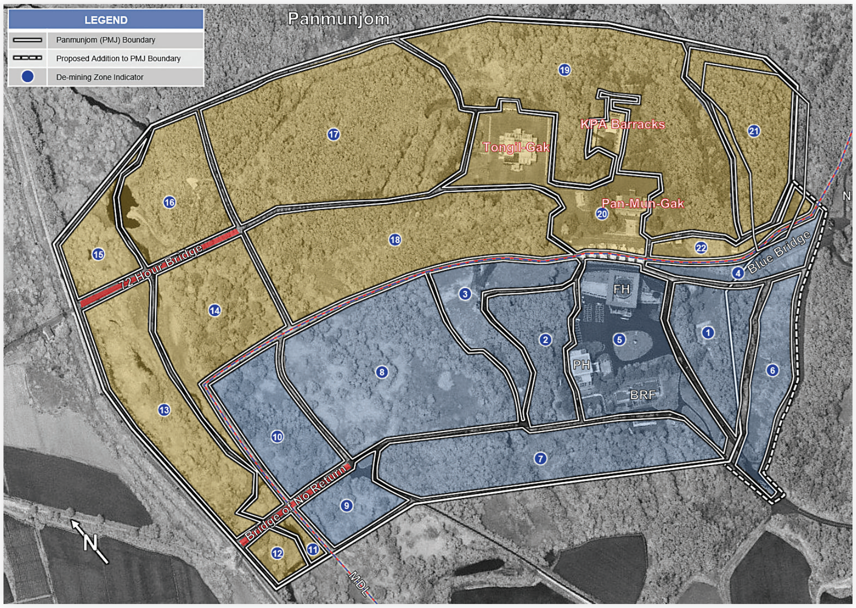

Figure 3. JSA demining zones.
Figure courtesy of LTC S. Morrow.

ROK-Army deminers at JSA.
Image courtesy of LTC S. Morrow.

being based on the International Mine Action Standards (IMAS)—adapted to the context and conditions of the DMZ.

Arrowhead Hill demining to support human remains recovery (Figure 2 Label 5). Atop of a little-known ridge in the Cheorwon Valley almost seven decades ago, French, South Korean, and American troops fought off waves of mainly Chinese communist forces in a series of trench battles that marked some of the bloodiest days of the Korean War. Hundreds of the fallen were never recovered. Of the Chinese and South Korean losses alone, it is estimated that 6,700 and 14,332 troops fell, respectively. Over a nine-day period, the U.S. Air Force dropped 2,700 bombs, the Chinese fired 55,000 shells, and South Korea fired 185,000 more around Hill 281, also known as Arrowhead Hill.[9]

Under the CMA, the first joint remains recovery task in the DMZ was conducted at Arrowhead Hill. This included the construction of a 3 km access road (1.7 km from the south side and 1.3 km from the north) to serve mine clearance and joint remains recovery operations.

The joint operations with the DPRK in 2018 did not continue when demining by the ROK resumed in the southern half of the DMZ at Arrowhead Hill in April 2019 following a deterioration of relations among parties to the conflict in early 2019. However, the ROK Army and UNC made a decision to continue the operation. When clearance concluded for the winter in November 2019, 102,688 sq m of land had been released, 455 mines and 5,754 UXO cleared, and 261 sets of human remains recovered.

Future plans for the human remains recovery program. The remains recovery program for 2020 is planned to first be completed at Arrowhead Hill. Beyond this site operations are envisaged to continue in the spirit of the CMA on a unilateral basis by demining units of the ROK Army supported by the UNC. In conjunction with records supplied by the Sending States,[10] operations will focus on additional battle sites not specified in the CMA that are expected to yield more remains. Possible sites may be drawn from the conflict zones such as Bunker Hill, Old Baldy, Iron Triangle, Northern Punchbowl, and Heartbreak Ridge.

Access route cleared by KPA to Arrowhead Hill to facilitate demining.
Image courtesy of MND Archives.

Human remains recovery, Arrowhead Hill.
Image courtesy of The Wall Street Journal.

Human remains excavation.
Image courtesy of UNC Archives.

Remains are honored.
Image courtesy of UNC Archives.

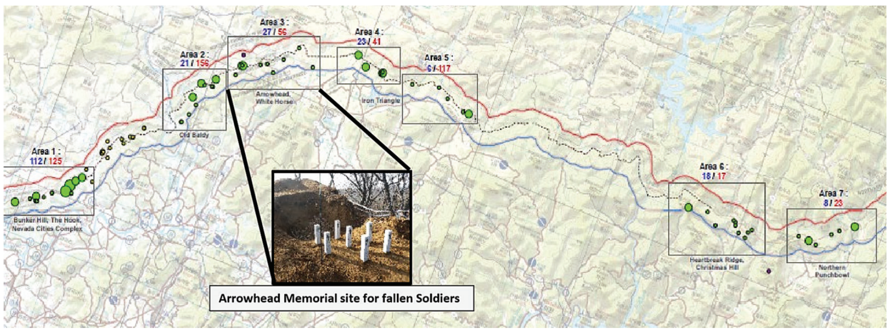

Figure 4. Battle site locations of potential DMZ Remains Recovery and Demining Operations 2020+.
Figure courtesy of a MND/UNC presentation, Geneva, February 2020.

Figure 5. Biodiversity report of the DMZ Area/MOE-NIE (2016).
Figure courtesy of Ministry of Environment, National Institute of Ecology (2016).

THE PHYSICAL ENVIRONMENT AND BIODIVERSITY OF THE DMZ

In his address at the 74th United Nations General Assembly (UNGA) in September 2019, ROK President Moon Jae-in described the DMZ as "a colossal green zone…its borders define a tragedy spawned by 70 years of military confrontation, but paradoxically, it has become a pristine ecological treasure trove."

Indeed, since the signing of the armistice in 1953, there has been a revival of wild habitats in the absence of human activity. According to the National Institute of Ecology (2018),[11] 6,168 species of flora and fauna have been documented in the DMZ with 102 species classified as endangered or vulnerable. These are spread across varied landscapes of wetlands, plains, and mountains from the Imjin River Estuary in the west to the coastal region of the east.

Conducting survey and clearance operations in this wildlife refuge carries a tremendous responsibility and demands the utmost respect for the environment. By its very nature, demining is disruptive, but there are many approaches to mitigate its impact. IMAS 07.13 Environmental Management in Mine Action is a good point of departure, but future National Mine Action Standards for Korea (yet to be developed) should be far more comprehensive and prescriptive in nature. The competing challenges of demining and environmental preservation call on heightened collaboration between authorities concerned with clearance operations and those institutions and ministries dealing with conservation of the natural habitat.

Appropriate demining methods and tools will need to be considered together with integrated planning and priority-setting approaches that are responsive to ecological sensitivities. In some cases, this may be achieved through timing and sequencing of operations that do not conflict with the nesting and mating cycles of endangered birds and mammals. In others, consideration of the diminishing risk from ageing ordnance may support a decision that certain areas of particular environmental importance will not be prioritized, at least not as a starting point. Considering the enormous size of the DMZ and the reality that clearance operations will take decades to complete, this would appear entirely reasonable,

13

especially if the threat from explosive hazards in these areas is low, poorly-defined, or deeply-buried. Mine action is about manageing risk from explosive ordnance; searching every square meter of the DMZ for explosive devices is unnecessary.

Certain conservation areas may be managed by continuing to limit or exclude human activity through signage and education. This would be consistent with some areas contaminated by explosive ordnance in Western Europe that remain "out of bounds" to the general public, such as the former Soviet military training range at Wittstock, Brandenburg, located in the former East Germany.

POTENTIAL ROLE AND CONTRIBUTION FROM THE INTERNATIONAL MINE ACTION COMMUNITY

International Seminar November 2018 – NGO's Role for Mine Clearance in the DMZ, including UNMAS, UNDP, ICRC, GICHD, HALO, NPA, APMBC-ISU, GMAP, FSD, ICBL, JCBL, and PCBL.
Image courtesy of the Peace Sharing Association (PSA).

At the 74th UNGA, President Moon also presented a vision to transform the DMZ into an international peace zone, "The DMZ has become a symbolic space steeped in history, which embraces both the tragedy of division as embodied by the JSA, guard posts and barbed-wire fences as well as the yearning for peace. The DMZ is the common heritage of humankind, and its value must be shared with the whole world. Once peace is established between the two Koreas, I will work together with North Korea to inscribe the DMZ as a UNESCO World Heritage Site." He went on to say, "Approximately 380,000 anti-personnel mines are laid in the DMZ, and it is expected to take 15 years for South Korean troops to remove them on their own."[12] However, cooperation with the international community, including the United Nations Mine Action Service (UNMAS), will not only guarantee the transparency and stability of demining operations, but also instantly turn the DMZ into an area of international cooperation."[13]

Notwithstanding security considerations, current legislation restrictions, and necessary solutions for appropriate funding mechanisms, the addition of the international community working in the DMZ would serve two principal objectives: (1) it would offer additional capacity, and (2) perhaps more important, it would be a significant step in further demilitarizing the border zone.

International NGOs and the United Nations strive to uphold the humanitarian principles of neutrality, impartiality, humanity, and independence; and could provide an additional "face;" and offer further tools and approaches to contribute to the goal of securing sustainable peace. They also come with thirty years of humanitarian demining experience—gained through working in conflict zones, humanitarian crises, peace-keeping frameworks, and in assisted development and development contexts. Such an international capacity should not be considered as competition to the highly-trained and equipped ROK Army demining units but rather a different type of capacity that presents additional opportunities.

International organizations are committed to assist in the world-wide clearance of landmines and UXO but are particularly motivated by contexts where mine action can also contribute to a greater goal. Nowhere is this potential more evident than on the Korean Peninsula. Although somewhat distant at present, future assistance may also be channeled through Pyongyang, although the sanction regime and position of the North Korean government currently render this prospect as fanciful. Demining on the Korean Peninsula, however, should be considered a long-term prospect.

The DPRK is a more natural partner for international organizations, as the ROK is not a recipient of aid—indeed it is a considerable international donor itself for mine action. The ROK is an economic heavyweight with a gross domestic product that exceeds many of the principal international donors such as Australia, Switzerland, the Netherlands, and Norway. However, the context on the Korean Peninsula is not a normal one. In order to maximize peace dividends, a coordinated approach that draws on national and international capacities and skillsets may be more effective.

Importantly, the UNC is unequivocal in its support of President Moon's vision of clearing the DMZ of landmines and UXO. This has been reiterated on several occasions by General Robert Abrams, the Commander of the UNC and U.S. Forces Korea. Furthermore, the addition of international expertise and capacity, including international NGOs, is also supported by the UNC.

Mine Action Workshop, January 2019. United Nations Command, US Forces Korea, Combined Forces Command, 8th Army, ICRC, UNMAS, ROK Ministry of National Defense, ROK Army, ROK MoFA, US Army Corps of Engineers, The HALO Trust, NPA, MAG, GICHD, US DoS, Norwegian Embassy, Netherlands Embassy, British Embassy, Australian Embassy.
Image courtesy of UNC Archives.

CONSIDERATIONS FOR STRENGTHENING OF MINE ACTION FRAMEWORKS ON THE KOREAN PENINSULA

Demining the DMZ is a considerable undertaking, which will take decades. Whether operations are upscaled soon or in a few years, it takes time to establish the legal, institutional, strategic, and operational frameworks to support such a considerable task. It is vital that an appropriate framework is established at an early stage in order to maintain confidence in the safety, quality, and environmental acceptability of survey and clearance operations whether they be delivered by military, commercial, or NGO capacities.

Institutions. It is important to establish an appropriate legal and institutional framework to accommodate expanding programs, particularly if a variety of demining operators are to be employed. Such a framework should define an architecture of regulation, management, and coordination. More than just a technical activity, demining has implications across ministries and sectors. This should be reflected in the governance structure with a view to corresponding architecture within the North Korean authorities.

There are many variations on institutional frameworks for mine action programs that have varying degrees of military and civilian representation and authority. In the context of Korea, this will inevitably be skewed towards the military. In a generic model, the most senior level—a National Mine Action Authority (NMAA), perhaps under the prime minister—is typically responsible for policy and coordination across ministries, which include those with implementation responsibilities (Defense and Foreign Affairs), those affected by contamination (Environment and Agriculture), and those with economic roles (Planning and Finance). The NMAA would normally approve the overall mine action strategy, national standards, annual workplans, and priorities. With jurisdiction over the DMZ in the ROK, the UNC should also be positioned appropriately for decision-making procedures linked to either the NMAA or the Mine Action Centre (MAC).

Below the NMAA, the MAC typically coordinates national and international operators. It manages daily operations that could include mine risk education and victim assistance, while also monitoring the quality of operations. The MAC would also be responsible for information management, including the national database, and developing national mine action standards (NMAS). The Ministry of National Defense (MND) may serve as a suitable host for such an office and function.

At an operational level, implementers could potentially be national or international organizations, military units, or non-profit/commercial entities. They operate in accordance with NMAS and are usually accredited and monitored by teams from the MAC.

Standards. A peace zone is compromised if accidents occur after demining operations take place or if the safety of the land is in question. Confidence-building measures can be damaged or reversed if mines remain in the ground and subsequent injury or death occurs.

A common reference framework could have been beneficial during the 2018–2019 operations at the JSA and Arrowhead Hill. Observations of the demining that occurred under the CMA, particularly to the north of the MDL, raised some questions about the reliability of the procedures and quality management systems in use.

The IMAS are the reference standards for the United Nations and international community, developed over the course of twenty years by a wide range of mine action stakeholders. The IMAS are used in over fifty countries, including by

- the UK government for clearance operations on the Falkland Islands,
- the US Humanitarian Demining Training Center as a basis for training US forces, and
- the Chinese military undertaking demining in Peace Keeping Operations.

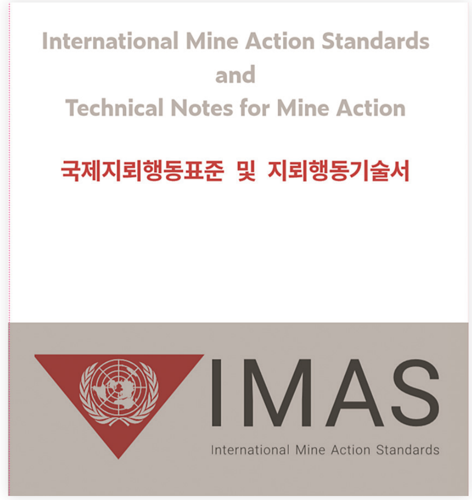

Figure 6. Front cover of the IMAS in Korean.
Figure courtesy of GICHD.

In 2019, the MND commissioned the Peace Sharing Association (PSA) to translate the IMAS into Korean. This was completed and provides a comprehensive set of documents from which to draw upon to develop the National (Korean) Mine Action Standards (KMAS). These should be adapted to the context of the peninsula while remaining compliant to the overarching IMAS.

The KMAS will be defined by the ROK authorities. If adopted, the KMAS would ensure that different organizations deliver a common and consistent approach to demining, ensuring safety, efficiency and effectiveness, and confidence that the quality of cleared land is maintained and assured.

Recent developments offer the option to database the Korean version of the IMAS to facilitate the navigation and interrogation of more than 1,000 pages of technical material. Such an exercise has only recently been completed for the IMAS in English.[14] Bringing the Korean version into the newly established IMAS database would provide the peninsula with a tool at the forefront of the global mine action sector.

By databasing the requirements and recommendations of IMAS, Korea will be able to dynamically filter the standards to create targeted checklists for self-assessment or external-compliance monitoring purposes. Korea could benefit from the work already done, which would allow a straightforward review of existing military doctrines against IMAS, identifying and addressing any gaps that may be present.[15]

Figure 7. Relationship between IMAS, NMAS, SOPs, and training material.
Figure courtesy of GICHD.

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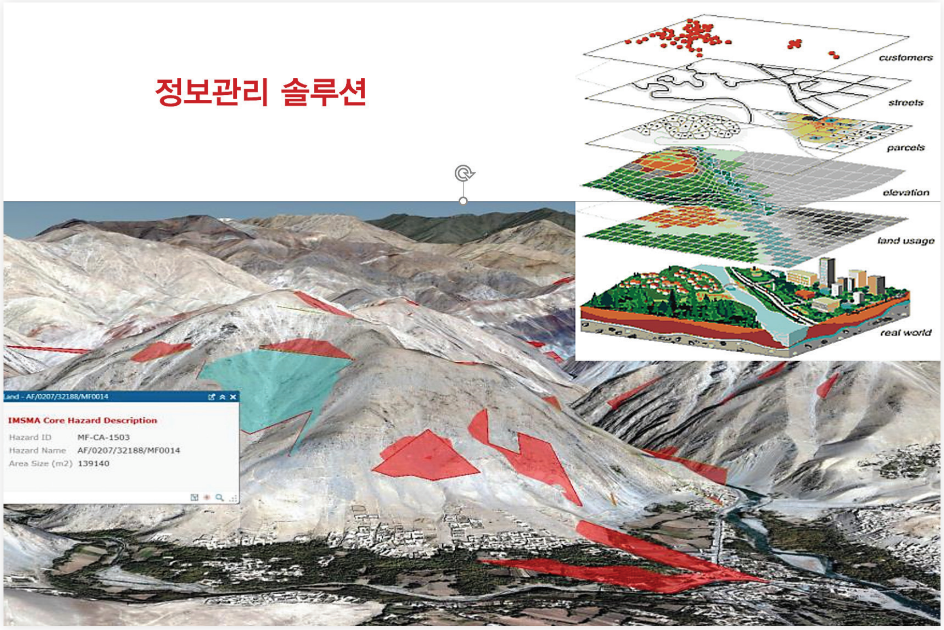

Figure 8. A visual example displaying mine contamination data.
Figure reproduction of a slide used by the author at the DMZ Global Forum in Seoul, November 2019.

The IMAS have a close relationship with international conventions on disarmament and are the reference point for donors and sponsors of mine action. International financial support will be important for the future of the peninsula, particularly initiatives in the north. Funding would be more forthcoming if programs operated within the recognized framework of IMAS. When conducive, moving towards a common framework for the entire peninsula has potential to be an important process.

Information Management. For the considerable task of demining the DMZ, a state-of-the-art information management system is essential. Databases and geographic information systems provide the means to inform decision makers and to manage and monitor operations. Moreover, they record what activities were completed where, when, and by whom. This safeguards against duplication, facilitates planning and reporting, and may be important to address any future liability considerations.

The information management database stores information on known or suspected areas of contamination together with other datasets such as access routes, vegetation cover, topography, land ownership, various war archive data, and environmental information—ideally in an integrated system to support planning and priority setting. It should be designed and developed with the whole DMZ in mind. Understanding that some data is sensitive, information management systems can easily be designed to have different levels of access and authority, but it is important to balance appropriate transparency with security and other considerations.

Research. There are many opportunities to share cross-border experiences and knowledge, but one research area stands out when considering demining and the importance of the preservation of the environment. This is the understanding of how risk changes as munitions age. What are the impacts of changing circumstances and conditions that surround mines and UXO on the Korean Peninsula? This has great implications when making informed decisions on priority setting and balancing risk from explosive devices with a desire to retain the integrity of a fragile environment.

PMD-6 box mine.

Weathered PMD-6 mine.

M16 mine with fuse and weathered M16 without.

Images courtesy of Fenix Insight Ltd.

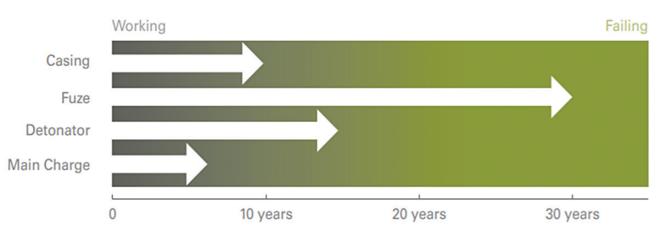

Figure 9. Generic illustration of the ageing process of different components of a mine.
Figure courtesy of Fenix Insight Ltd.

The ageing process affects different devices in different ways. The energy required for arming and initiation of mines is often supplied by springs. Where springs have corroded, the munition is incapable of functioning as designed. For instance, the wooden box mine, which is understood to have been widely used by North Korean forces, has a case that is prone to disintegrate over time.[16] It also has a fuse with a firing chain that can be disrupted by corrosion. In the south, the M16 mine is metallic and rusts over time. It may become unrecognizable. Other mines such as the M14 anti-personnel mine are more resilient. However, there is some reassurance that mines will pose a diminishing risk in the long term, but it is difficult to quantify.

THE VISION FOR MINE ACTION ON THE PENINSULA

However fanciful, programs should have a vision. The vision for the Korean Peninsula is that an architecture for demining the DMZ is jointly owned by both North and South Korea, and that demining operations address shared objectives and priorities and are undertaken in accordance with common practices within a framework of recognized international norms.

Figure 10. A vision of linked institutions, joint mine action strategies, and operations on the Korean Peninsula.
Figure courtesy of the author.

When it eventually comes, the signing of a Peace Agreement will provide an opportunity to establish a more integrated institutional framework with North Korea to reinforce a unified approach to demining the DMZ. This could involve elements of a joint authority and steps towards a common MAC. In the meantime, much can be done unilaterally to advance mine action programs, involve the international community, and explore further how mine action activities can be used to build confidence on the Korean Peninsula.

SUMMARY OF RECOMMENDATIONS

Peace on the Korean Peninsula remains a long process, and while the climate for confidence-building opportunities is currently at a low ebb, landmines in the DMZ do not go away. Nor do the opportunities that mine action offers to contribute to reconciliation and peace.

It takes time to adapt an architecture for mine action outside a purely military lens, but this is necessary to establish the fundamentals needed to underpin all opportunities for mine action in the future. President Moon has a vision for a peace zone in the DMZ free from mines and UXO, and he believes that cooperation with the international community will both guarantee the transparency and stability of demining operations and help turn the DMZ into an area of international cooperation. This vision is supported by the UNC.

To help prepare for future work, the relevant authorities could benefit from considering five key recommendations to help achieve this vision.

First, adjusting national legislation for mine action to allow non-military capacities to contribute to demining.

Second, ensuring that the institutional and strategic frameworks for mine action reflect the inter-ministerial nature of the problem and support a longer-term goal of a joint mine action architecture for the entire peninsula. The MND in its appropriate role could also strive to be more accessible and open for exchange.

Third, further adaptation of operational frameworks such as standards in operations (including quality management systems) of the military and alignment with recognized international norms and practices. The development of KMAS based on IMAS offers an early and significant opportunity in this respect.

Fourth, pursuit of research and international exchange on pertinent issues of relevance to Korea. For example, the management of risk concerning ageing explosive ordnance, mitigation approaches towards environmental impact, advanced prioritization schemes for operations, and appropriate information management systems and processes that are fit for purpose.

Fifth, promotion of information sharing and appropriate transparency with the DPRK to inform the process of developing a mine action machinery that is geared toward peace, not war. Optics are important. Consideration could be given to having deminers dressed in a neutral attire rather than military fatigues.

These suggested adjustments to the mine action ethos and architecture in Korea will help ensure the success of operations, where "success" will be measured in peace dividends that are linked to safety and confidence of cleared land and the value of activities that mine action helps to facilitate.

In the absence of collaboration with the DPRK, a reformed mine action sector in the ROK will be beneficial to support unilateral activities. It will also ensure that the ROK is well equipped to accommodate all confidence-building opportunities that mine action can offer, and in addition, position itself to support the inevitable upscaling of operations in the future.

See endnotes page 68

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17

DISPOSAL OF EXPLOSIVE ORDNANCE AND ENVIRONMENTAL RISK MITIGATION: TIME FOR HUMANITARIAN MINE ACTION TO CATCH UP?

By Roly Evans [GICHD] and Andy Duncan

Humanitarian mine action (HMA) survey and clearance operations have always focused on the contamination that can be seen. Whether it is anti-personnel (AP) mines, anti-vehicles (AV) mines, or explosive remnants of war (ERW), our efforts focus on removing items that pose an immediate blast and fragmentation hazard to humans. However, in certain circumstances, explosive ordnance (EO) also poses a significant environmental hazard, not least from the toxicity of its components, such as heavy metals and explosives. The understanding of contamination from EO in air, soil, and water has developed significantly in recent decades.[1-4] This has mainly been driven by scientists and industry, as well as military users required to focus on the environmental impact of military training, and led to the development of improved management practices to mitigate the associated environmental risk.[5-8] In some countries this has resulted in significant policy change. Notably the tonnage of munitions disposed of by open burning open detonation (OBOD) by the United States Department of Defense decreased by 58 percent during the period 1998–2018.[9] In comparison, it is not clear that HMA is universally applying best practice to mitigate the chemical contamination risk from its clearance and explosive ordnance disposal (EOD) activities. A sector that follows simple principles such as "do no harm" and ostensibly always seeks to apply "all reasonable effort" might wish to review and update its current approach.

HMA often operates in environments where perfection may be deemed the enemy of good. What is practicable on a military range in the United Kingdom might not be so in the complex environments of current HMA operations. Therefore, the task is to develop practical mitigation methods that have a good chance of being applied, no matter the location. Examples of such methods could range from using an inexpensive kit to check the pH of soil for a central demolition area, to more training to recognize and safely dispose of munitions containing heavy metal tungsten alloys (HMTA). A number of practical improvements are possible. The first step for HMA organizations is to recognize the issues and then implement better methods accordingly.

LEGISLATION

Relevant legislation tends to cover broad principles of pollution rather than specific contamination types such as those from EO. Such international legislation that does exist governs the disposal of munitions that cross international borders and, as an example, preclude the dumping of munitions at sea. The European Union's Water Framework Directive 2000/60/EC[10] and the United States Clean Water Act 1972[11] are important reference points. In the United Kingdom, the Water Resources Act 1991[12] and the Environmental Protection Act 1990[13] are the key pieces of legislation. Beneath the level of legislation, the International Ammunition Technical Guideline (IATG) 10.10 specifies the need for national authorities to set the standards governing environmental protection within national borders,[14] but how much this has been applied globally is open to question.[15] IMAS 07.13, Environmental Management in Mine Action, does "not enforce specific practical mitigation measures but is a framework giving the tools for the NMAA to define these."[16]

THE ENVIRONMENTAL IMPACT OF HMA

HMA damages the environment. A certain level of damage is inevitable. Traditionally this damage has been associated with the physical process of clearing land of AP and AV mines. To clear land invariably requires most vegetation to be removed, with the possible exception of trees above a certain size, alongside physical excavation of the topsoil. This damage was, and is, accepted as an inevitable part of the demining process. Typically, the damage would not be permanent, and the land re-used relatively quickly. Locals often welcome the clearance on the basis that the land will be easier to cultivate once mine action has not only removed the mines but also removed much of the vegetation and made the soil easier to work.[17] Clearance operations among sand dunes have required the remediation of the environment, once the clearance is completed, as was the case in Skallingen up to 2012.[18] Aside from the potential physical damage, mine action organizations also impact the environment in the same way most human activity does, be it emissions from vehicles or generators, human waste, etc. It is this generic impact that has been, to a degree, addressed within IMAS 07.13 and in standard operating procedures (SOPs).

The chemical contamination from explosives has often not been recognized or understood by clearance operators. Few SOPs include direction on how to mitigate the environmental impact of burning small arms ammunition (SAA), open burning or open detonation of high explosive natures, destruction of certain types of white phosphorous, or destruction of armor penetrating ammunition containing HMTA. Furthermore, at some point HMA operators will encounter EO containing insensitive explosive formulations, the inherent environmental hazards of which are subject to continuing research. These formulations present a potentially different pollution hazard compared with traditional munitions. Such contamination is or will be part of HMA's environmental impact, and operators are responsible for the contamination that could reasonably have been prevented during clearance and disposal operations.

SMALL ARMS AMMUNITION (SAA)

Most SAA contains lead, along with smaller amounts of alloying material such as antimony. Lead slag is classified as Toxic Solid UN 6.1 (UN ID 3288).[19] The U.S. Department of Health and Human Services Food and Drug Administration states that in "humans and animals, exposure to lead may cause neurological, reproductive, developmental, immune, cardiovascular and renal health effects. In general, sensitivity to lead toxicity is greater when there is exposure in utero and in children compared to adults."[20]

The safe disposal of SAA presents a significant ongoing challenge to HMA clearance operators. The days when SAA was added to bulk demolitions are hopefully long in the past. Currently, most SAA is burnt in some way. Open pit burns used to be one technique used, but this method is guaranteed to introduce lead contamination directly into the soil. Organizations have developed improvised or bespoke burning tanks that, if strong enough, are also used to burn the primers and boosters within fuzes of a certain size. Military organizations have increasingly used industrial rotary kilns. The capital expenditure these require has meant they are yet to be deployed in HMA.

Regardless of the method of burning, the slag residue from SAA is typically buried. This is potentially a significant risk to the environment, especially if done in large quantities. Burial without knowledge of local soil and water course conditions is a practice that should cease in HMA. Many operators are unaware of the concept of fate and transport of lead contamination. In simple terms this follows a source-pathway-receptor (SPR) model, with lead being the source in this instance. The pathway would be the means by which the contaminant moves through the environment; by air, soil, or water. The receptor is the entity that can be adversely affected by the contaminant.[21] The transport depends on contaminant solubility, which in turn is governed by pH and oxidation. Lead is an amphoteric metal that exhibits its greatest solubility in acidic ($pH < 4$) and heavily alkaline ($pH > 11$) solutions.[22] "Lead corrodes and leaches readily in acidic conditions to concentrations that can exceed guidelines for human health and controlled waters."[23] Despite this risk, no current HMA SOPs are known to detail even a basic environmental risk assessment prior to the burial of SAA slag residue, or even possible mitigation measures.

HEAVY METAL TUNGSTEN ALLOYS

The concern over the alleged carcinogenic effects of depleted uranium (DU) since 1991 lead to the development of tungsten alloys as an alternative for armor piercing ammunition.[24] Unfortunately, tungsten alloys have been the cause of increasing concern for those charged with mitigating the environmental impact on military firing ranges. Tungsten alloys have been proven to be carcinogenic during animal testing.[25,26] The main risk for HMA staff and civilians who may come into contact with HMTA are sintered[27] splinters piercing the skin and

An SAA burn pit. The SAA was burnt in an open pit with a simple metal cover. The slag residue was subsequently buried. This method is hopefully no longer used by operators. Burying the slag residue from SAA pit burns concentrates the toxic waste and is potentially a significant pollution risk.
Image © Private.

subsequently becoming embedded, especially for alloys combining tungsten with nickel or cobalt.[28] HMTA ammunition, whether it is from SAA or long rod penetrators, is far more likely to sinter if added inadvertently to bulk demolitions. In a worst-case scenario, whether by means of a single item demolition or as part of a bulk demolition, an unknowing operator could spread dangerous WNiCo splinters[29] into the environment posing a risk to themselves, other humans, and animals.

ENVIRONMENTAL IMPACT OF TRADITIONAL EXPLOSIVE FILLS

Most high explosive munitions contain one or both of Cyclotrimethylenetrinitramine (RDX) or Trinitrotoluene (TNT). Munitions containing RDX invariably contain a small percentage of cyclotetramethylenetetranitramine (HMX) and more modern shaped charges will often have HMX as the key energetic ingredient. All three explosives have some degree of toxicity.[30] The nitro aromatic TNT can undergo degradation to form the 2,4 Dnitrotoluene (DNT) isomer, a common biodegradation product of TNT that displays greater toxicity. DNT can convert haemoglobin to methaglobin[31] at a relatively low threshold limit of 0.13 mg/L and is therefore listed by the United States Environmental Protection Agency (EPA) as hazardous waste.[32] DNT is highly toxic to humans.[33,34]

The nitramine RDX has been designated a possible human carcinogen (categorization C) by the EPA. The EPA has set drinking water advisory limits for TNT, RDX, and HMX.[35,36] TNT and DNT tend to bind to organic matter in the earth and therefore don't transport as readily as RDX, which has greater potential as a pollutant of groundwater.[37]

These explosives present a particular issue for HMA operators since much of the EO destroyed by the sector is by means of second order detonation, i.e., a donor charge is used to shatter the casing and initiate the main charge by means of sympathetic detonation. Some high explosive munitions, especially thin-cased mines, may be destroyed by burning. There is now substantial evidence to suggest that both methods will result in significant levels of energetic residue compared with a first order detonation, where the munition fuzing system detonates the main charge as intended after firing.[38,39] Testing of military firing ranges over time suggests that contamination tends to stay in the topsoil, approximately the first 30 cm, depending on the soil type.[40,41] For HMA operators the risk is highest in areas where high EO is repeatedly destroyed by second order demolition, i.e., a central demolition site (CDS), a process sometimes referred to as "residue loading." This risk is higher in areas with moderate or high levels of precipitation, a shallow water table, slow moving groundwater, and proximity to a water course.[42] What measures do HMA operators currently take to monitor and limit the explosive residue contamination from second order demolitions?

(Above) An inert cutaway of the new HMTA 40 mm telescopic APFS-DS-T round. Ammunition containing HMTA, especially WNiCo alloys, pose a hazard to humans if sintered splinters puncture the skin. Are we training HMA EOD operators to correctly identify and dispose of such ammunition?
Image courtesy of Andrew Duncan.

INSENSITIVE MUNITION EXPLOSIVE FORMULATIONS

Many NATO countries are developing insensitive munitions (IM). Typically, this development concentrates on the high explosive fill, with traditional formulations such as Composition B (60 percent TNT, 40 percent RDX), being replaced by formulations containing reduced vulnerability energetic materials. These will have high thermal stability and will to some degree be resistant to shock. Explosives such as Nitrotriazolone (NTO) and 2,4-Dinitroanisole (DNAN) are key ingredients for the new US insensitive explosives, IMX-101 and IMX-104, being fielded for gun artillery and mortars respectively. Both NTO[43] and DNAN[44] are undergoing further study to assess acute and chronic toxicity on the environment and humans.[45] In terms of residue deposited from IM munitions, recent testing has shown that standard methods of high order for single items of high EO leave significantly more explosive residue.[46,47] For example, PAX-21, an insensitive formulation of RDX, DNAN, and ammonium perchlorate, can deposit residues of up to 28 percent of the perchlorate, even during first order detonations.[48] Ammonium perchlorate residues are also common at firing points, and it may therefore be assumed in areas where HMA operators burn propellant, residues will also be high. The US EPA identifies the chronic exposure to perchlorate, (even at very low levels), as interfering with the iodine uptake into the thyroid gland.[49]

WHAT PRACTICAL STEPS CAN BE TAKEN?

The first and main practical step for HMA operators to take is to ensure that their professional knowledge of explosives remains current, and to update their procedures accordingly. This requires developing SOPs detailing how they will minimize the risk of chemical contamination from the disposal of EO including SAA. These should include direction on the safe disposal of SAA slag residue, ideally contracted through specialized waste disposal companies. Since these are invariably not present in many countries, at a minimum, operators should ensure that no slag residue is buried in acidic soils and should conduct the simple tests to ensure this. (A simple soil pH testing kit can be purchased for as little as USD$10.) If there is no other option but to bury SAA slag residue, it should be sealed in watertight plastic barrels to prevent leaching into the surrounding

Bulk demolition using binary liquid explosive. How much explosive residue may be deposited by repeat bulk demolitions at central demolition sites by HMA operators? Are EOD operators aware that such techniques will need to be adapted for insensitive munitions? Are EOD operators aware of the risks of adding HMTA ammunition to such a demolition?
Image courtesy of Roly Evans.

soil. For destruction of large quantities of SAA associated with a national stockpile this presents a logistical challenge since large quantities of barrels will be required.

Large-scale disposal of propellants and pyrotechnics often leaves an obvious area of contamination on the soil. Most of this contamination stays on the surface until rainwater washes it into the subsoil. Having considered the proximity of local water courses, where deemed practical, consideration may be given to the mechanical excavation and removal of this residue. It can then be treated in the same way as SAA slag is dealt with. The Canadian military developed a burning table technique for their artillery units to avoid open burning of excess propellants following live firing exercises[50] and it is possible the technique could be adapted for use in HMA.

In order to mitigate the actual residue deposition from second order demolition, operators should consider increasing the amount and quality of donor charge used, especially for repeat bulk demolitions at a CDS. If the fuze well is empty, as might be the case for destruction of stockpiled ordnance or abandoned explosive ordnance (AXO), operators are advised to use this for donor charge placement in order to maximize the chance of a first order detonation. Assuming some residue is unavoidable, operators should be careful about the sites selected for CDS. Again, acidic soil is likely to enable greater transport of contaminants and therefore soil at CDS should be tested. Ideally CDS should be a good distance from water courses and known groundwater locations.

Although IM are not yet commonly encountered within HMA, operators should understand the impact of their insensitivity during disposal. When destroying unfuzed ordnance from stockpiles, a donor charge placed in the fuze well should ensure full detonation. This is because the IM requires confinement to fully detonate, and a donor charge that is placed on the outer casing will have reduced the confinement before detonation of the internal explosive occurs. Alternatively, if the fuze well cannot be utilized, a shaped charge aimed at the booster is the best means of minimizing explosive residue.[51,52] Further testing is required to determine if IM can be effectively destroyed through sympathetic detonation by means of bulk demolition.

For both SAA burning sites and CDS (often the same location), operators should consider instituting a soil sampling regime. The time and the cost might be deemed impractical but ultimately HMA operators need to monitor at-risk locations in order to manage the potential contamination their disposal activities may create.

In order to mitigate the potential harm from HMTA, the key action for operators is to ensure all technical staff can accurately identify EO containing HMTA, whether it be SAA or a 125 mm long rod penetrator. Such munitions should not be disposed of through standard OBOD techniques. HMTA should be handed over to the competent authority for processing.

CONCLUSION

As research continues, understanding of the actual chemical contamination risk from EO evolves. Even in defense circles, where most of the funding for this research originates, there is a wide appreciation that there is plenty more left to learn.[53] Nevertheless, those responsible for mitigating environmental contamination in modern defense organizations are far in advance of HMA on these issues, not least since they tend to operate within legal frameworks that are becoming ever more stringent in regard to pollution of the environment.[54] Countries such as Germany and the Netherlands banned domestic use of OBOD in the 2000s[55,56] and elsewhere its use as a demilitarization method is subject to ever more stringent restrictions.[57] OBOD techniques are "strictly prohibited" within the framework of industrial demilitarization contracts managed by the NATO Support and Procurement Agency (NSPA), although they are permitted in other contracts.[58]

HMA operators still have much to do in order to make sure they are applying all reasonable effort in order to minimize the risk of chemical contamination from the munitions they clear. HMA is in no position to stop OBOD, and it is in no way appropriate that it should. However, HMA is able to make sure it is done in a way where risks are responsibly managed. There are practical measures that can be taken, and these should be integrated into the relevant technical documents, including operator SOPs. Hopefully HMA operators will one day not find themselves in a position where their best intentions of removing EO have been undermined by an inadvertent act of pollution that could reasonably have been avoided. We should actively avoid doing the wrong thing in the wrong place under the wrong conditions. While actual

A detonation plume from a high explosive ordnance residue test in Alaska. Snow is the perfect medium for measuring the environmental deposition of energetics. Researchers at the Cold Regions Research and Engineering Laboratory (CRREL) used various techniques to simulate low-order detonations with both traditional and insensitive high explosives fillings.
Image courtesy of Michael Walsh/CRREL.

IMX-104 fill spread after a low-order technique. Second order and low order techniques are prone to leave more residue. Researchers at the CRREL in Alaska have used various techniques to simulate low-order detonations with insensitive high explosives fillings.
Image courtesy of Michael R. Walsh/CRREL.

explosive hazards have arguably a more immediate significance to the people we are trying to help, reputational risk to HMA organizations is real, as of course are the moral and legal risks.

In terms of the environment, it is virtually impossible for HMA organizations to "do no harm." Clearing ground of EO, especially landmines, inevitably has an environmental impact, whether it is vegetation clearance, physical damage to topsoil or contamination of soil and water by toxic energetics. The key will be to show we are making "all reasonable effort" to minimize environmental contamination to a level no more than necessary to remove the immediate blast and fragmentation hazard.

See endnotes page 68

The authors wish to sincerely thank Dr. Tracey Temple at Cranfield University for her advice during the writing of this article and Dr. Michael R. Walsh for his kind permission to use his images.

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MEASURING BEHAVIOR CHANGE RESULTING FROM EORE AND THE NEED FOR COMPLEMENTARY RISK REDUCTION ACTIVITIES

By Helaine Boyd [HALO], Sebastian Kasack [MAG], and Noe Falk Nielsen [NPA]

FGD with a mixed community group in Olmun Village, Battambang Province, Cambodia. Good notetaking and facilitation are key.
Photo courtesy of © Sean Sutton/MAG.

Risk education (RE) in mine action has been around since 1992.[1] However, explosive ordnance risk education (EORE)[2] operators are still struggling to measure how and whether EORE has resulted in positive behavior change.[3] Of course, various monitoring and evaluation (M&E) methods have been pursued in the past, predominantly the use of knowledge, attitude, practice, and beliefs (KAPB) surveys; simpler pre-/post-EORE session surveys; the use of proxy indicators such as number of explosive ordnance (EO) accidents or victims; and number of explosive ordnance disposal (EOD) callouts from the community. However, these methods come with some limitations in accurately capturing behavior change. For example, survey questions linked to behavior would normally be prefaced as "what would you do if…" However, this self-reporting of behavior does not necessarily capture actual behaviors; moreover, responses may be biased toward giving the "correct answer" in order to please the organization conducting the survey. Further, research has evaluated the limits of EORE in the context of ongoing conflict, high levels of poverty, and/or insufficient clearance/ordnance disposal capacity. These circumstances lead to a lack of choices for persons living in or near an EO-contaminated environment to adopt safer behavior.

This article presents a new approach to measuring behavior change, using a combination of qualitative and quantitative survey methods. It is centered around conducting focus group discussions (FGDs) pre-/post-EORE interventions at the community level. The approach is showing positive results after an initial round of piloting and implementation in ten countries (Angola, Burma, Cambodia, Laos, Lebanon, Somalia, South Sudan, Sri Lanka, Vietnam, and Zimbabwe) for the past eighteen months, but it is not without its challenges.

REASONS FOR DEVELOPING THIS METHODOLOGY

The HALO Trust (HALO), Mines Advisory Group (MAG), and Norwegian People's Aid (NPA) are partnering together as part of the UK Department for International Development's (DFID) second Global Mine Action Programme (GMAP2), which runs from 1 July 2018 to 31 March 2021 and covers the ten countries listed previously.

23

HALO staff conducting a focus group discussion with a mine-affected community in Anlong Veng District, Cambodia.
Photo courtesy of The HALO Trust.

While the "Partnership" had agreed on a standardized EORE pre-/post-survey approach in GMAP1, we realized methods for systematically measuring behavior change, particularly at a community level, were inadequate.[4] Difficulties in measuring behavior change during GMAP1 led the UK government to recommend the three organizations to seek improved ways of measuring the effects of EORE. Itad, an external organization contracted to provide monitoring and evaluation of the Partnership's work under GMAP, had written a summative evaluation report for GMAP1 that recommended "to really deliver behavioral change, better analysis is needed that leads to nuanced delivery of MRE."[5]

From this, the Partnership developed the following indicator to measure behavior change for the GMAP2 contract: "Percentage of impacted communities surveyed reporting an increase in people who behave in a safer manner (as a consequence of EORE)."

The Partnership began piloting a qualitative approach to measure behavior change through FGDs as this methodology would (*a*) allow for open discussions in small groups between five and twelve people to ask follow-on questions and explore topics in-depth (*b*) be more representative of the community's behavior rather than individual behavior, and (*c*) allow participants to report observed behaviors of other community members, which would not be possible from a quantitative KAPB survey. FGDs allow implementers to draw upon respondents' attitudes, feelings, beliefs, experiences, and reactions in a group setting.[6,7] By focusing on select age, social, and gender groups, FGDs can create an atmosphere where people feel free to talk. Further, by having a specific, thematic focus on behavior towards EO, this also provides a concise parameter for discussion.

While mine action operators are used to conducting group interviews and FGDs in other areas related to humanitarian mine action, the Partnership felt that we had not fully utilized FGDs in a comprehensive, rigorous manner to assess behavior change with respect to EORE. Key questions included: How were we going to produce a quantitative score to a qualitative-heavy methodology? How will we capture EO-related behavior of an entire community? We realized that rolling out this methodology was not going to be easy and would require additional training of our in-country community outreach teams (COTs)[8] in order to capture the nuance of varying behaviors and the underlying motives across differing sub-groups within communities.

DEVELOPING THE METHODOLOGY

Core parameters were quite clear: the COTs would conduct FGDs before the delivery of EORE sessions in a given community and then again about three-to-six months after the EORE intervention.

As it was the first time that this outcome indicator was used in DFID's GMAP, there was an element of "piloting" M&E for this indicator in the first three months of the project. Following this baseline phase, a lessons learned document was produced to catalogue all challenges and limitations in order to refine the methodology. The exercise determined that one FGD per community is not enough and if possible, multiple FGDs should be conducted with distinct groups, such as local leaders, women, youth, and/or specific risk-takers such as shepherds. Country contexts are wide-ranging during conflict, post-conflict, and in-development; and community acceptance of mine action activities and participatory approaches can vary widely depending on these circumstances. The capacity of our COTs also varied significantly. Too many of our staff were used to asking suggested questions in a script-like fashion, and did not probe deeper; and most importantly, they asked leading questions and judged participants' answers. Initially, we had envisioned that the FGD methodology would have a sample size of 20 percent of all communities where EORE is being conducted under the GMAP2 contract. However, it was later found that for some countries this was an overwhelming burden

Examples of some of the open-ended questions include:

- **What do you consider are safe behaviors towards EO?**
- **What are unsafe behaviors?**
- **What do you do when encountering explosive ordnance in contaminated areas?**
- **What reasons, if any, prevent you from taking a safer approach to the explosive ordnance threat?**

There are approximately nine to ten questions asked in each FGD, with the potential for numerous follow-up questions depending on the responses given.

Scoring Matrix (on a scale of 1–5, 1 being very unsafe to 5 being very safe)			
	#	The FGD exhibits the following behaviors/overall assessment	Examples
	1	FGD participants/community members are knowingly engaging in very unsafe activity/or it is implied that this activity is still happening, despite no strong reason for economic necessity. (the Reckless) FGD participants/community members engage in unsafe behavior because they are mostly not aware of the threat. Common belief that EO is not dangerous. (the Unaware) No one, or very few members in the community/FGD participants are engaging in actively safe behaviors (reporting to authorities, warning others not to enter suspected dangerous areas)	• Refugees or IDPs in a conflict affected country moving into contaminated areas without any knowledge of RE messaging • Ex-military or young boys who are reckless and refuse to believe EO is dangerous • Scrap metal collectors/explosive harvesters
	2	FGD participants/community members are aware of the threat, but do not know sufficiently how to behave more safely. (the Uninformed) FGD participants/community members knowingly use contaminated land (not applicable for cluster strike areas) due to economic desperation, but may use well-trodden pathways while doing so to avoid hazards. (the Forced) Very few, or at least less than the majority of members in the community/FGD participants are engaging in actively safe behaviors (reporting to authorities, warning others not to enter suspected dangerous areas)	• Poor communities using the land for cultivation out of desperation • Women/vulnerable groups who are isolated in rural communities and do not receive adequate RE
	3	A majority of FGD participants and other community members do not actively use the contaminated land; they seek safer areas for their livelihoods; unsafe behavior seems to be out of a misunderstanding of key RE messages or lack of trust of clearance response (i.e., moving an item to a tree or landmark to avoid the item being in the pathway of someone else) (the Misinformed/Forced) or fear (i.e., when an item is found, it is no longer picked up, but communities may not report to authorities out of fear of retribution). Half or a small majority of members in the community/FGD participants are engaging in actively safe behaviors (reporting to authorities, warning others not to enter suspected dangerous areas)	
	4	FGD participants/community members do not report any unsafe behaviors, hazardous areas are avoided, and people who did unsafe practices in the past have stopped doing so. A large majority of members in the community/FGD participants are engaging in actively safe behaviors (reporting to authorities, warning others not to enter suspected dangerous areas)	
	5	FGD participants/community members report mostly safe behaviors, and have actively and consistently reported items to authorities; they warn their children and newcomers about the threat. All or at least a 90% majority of members in the community/FGD participants are engaging in actively safe behaviors (reporting to authorities, warning others not to enter suspected dangerous areas)	• Communities with legacy contamination who have been living with mines for a long time and have a well-established reporting response mechanism to authorities

Table 1. Scoring matrix (on a scale of 1 to 5, 1 is very unsafe, 5 is very safe).
Table courtesy of authors.

on COT planning and would threaten the delivery of EORE session targets in some cases. Jeopardizing the humanitarian objective of the project was not an option. The sample size was thus redefined as "up to 20 percent of communities" to allow for some flexibility.

Specific and comprehensive guidelines were developed following the lessons learned exercise. Notably, better guidance was needed to properly train COTs. For example, finding the exact same participants for post-EORE FGDs is no longer binding to allow for some flexibility when gathering participants for the post-EORE FGD, as long as they had participated in the EORE session in the first place.

Analyzing the results of each FGD and then for the entire community may possibly be the riskiest part of this approach. The reasons for ranking a community in relation to its behaviors toward EO must be well explained. The matrix itself along with the guidance will likely need to be refined over time as more lessons are learned.

THE METHODOLOGY

The FGD methodology allows for capturing qualitative information, which is imperative in measuring behavior change through a quantitative scoring process. COTs raise with the participants a series of core topics, each with open-ended and follow-up questions, with the purpose of obtaining detailed information on behavior toward EO in the community. Examples of some of the open-ended questions include: What do you consider are safe behaviors towards EO? What are unsafe behaviors? What do you do when encountering EO in contaminated areas? What reasons, if any, prevent you from taking a safer approach to the EO threat? There are approximately nine to ten questions asked in each FGD, with the potential for numerous follow-up questions depending on the responses given.

From there, the COTs record comprehensive notes of the FGD. These notes are then immediately analyzed by the facilitator and note taker,

25

State/ Region	Teams	FGDs	1st Round Community Safety Score					2nd Round Community Safety Score				
			1	2	3	4	5	1	2	3	4	5
Shan	1	9		3	3	3				1	8	
Kayin	2	12	1	1	9	1		1	2	7	2	
Tanintharyi	2	36		6	11	19		1	1	2	32	
TOTAL	**5**	**57**	**1**	**10**	**23**	**23**	**0**	**2**	**3**	**20**	**42**	**0**
			1.8%	**17.5%**	**40.4%**	**40.4%**	**0.0%**	**3.5%**	**5.3%**	**17.5%**	**73.7%**	**0.0%**

Table 2. MAG FGD analysis in Myanmar. Number and absolute scores of FGDs before and after conducting EORE.

State/ Region	Communities	Lower Score	Same Score	Higher Score
Shan	9	0	3	6
Kayin	12	4	5	3
Tnintharyi	36	3	17	16
TOTAL	**57**	**7**	**25**	**25**
		12%	**44%**	**44%**

Table 3. MAG FGD analysis in Myanmar. Comparison between pre-EORE and post-EORE FGD scores.

with non-biased analysis provided by a senior member responsible for community liaison and EORE. The person responsible for analyzing the FGD data then produces a summary paragraph explaining the current state of behavior towards EO. This summary may include identifying the risk profiles of a community, with the understanding that multiple risk profiles may be present in a community at any given time. Risk profiles are broken down into five categories and can be ascribed to individuals but also groups, ranging from **Unaware, Uninformed, Misinformed, Reckless, to Forced.**[9]

SCORING SYSTEM

The scoring matrix ranks communities on a scale from one to five: from a very high risk-taking community (#1) to one where a majority of members in the community conduct safe behaviors related to EO (#5).

It is important to note that this scoring matrix comes with a number of caveats that are detailed in the overarching FGD guidance document.[10] Primarily, scoring of an FGD session should be done with the understanding of whether a majority or minority of community members carry out safe or unsafe behaviors toward EO. We have termed this the "none/some/all" approach to scoring. Further, the scoring of the post-EORE FGD three-to-six months later should be mindful of the summary paragraph from the pre-EORE FGD to see if the amount of community members exhibiting unsafe behaviors has reduced since the EORE session. Without this general quantifying of community members, it will become difficult to give a realistic score as it is quite likely for a community to exhibit both safe and unsafe behaviors at the same time.

OUTCOMES: SUCCESSES AND CHALLENGES

A positive outcome from using this methodology has been that it has increased trust between affected groups and mine action operators in communities, which has been significant in the context of **Myanmar**, where conflict sensitivity is paramount.

Talking about EO in Myanmar is still a very sensitive subject, even in areas where there has been no fighting for years. MAG Community Liaison staff conducted pre-EORE FGDs in eighty-three communities in three different States/Regions and post-EORE FGDs in fifty-seven of these communities (see Table 2).

Although there are still two communities that reported knowingly engaging in unsafe behaviors (Category 1), there has been a 12.2 percent decrease in the number of communities knowingly engaging in unsafe behavior out of survival imperatives (Category 2), and a 22.9 percent decrease in the number of communities that report examples of unsafe behavior stemming from ignorance or fear (Category 3). In the second round of FGDs, 73.7 percent of targeted communities did not report any unsafe behaviors but did not consistently report items to authorities (Category 4), a 33.3 percent increase from the first round.

A surprising result showed 12 percent of targeted communities received a lower score in the post-EORE FGDs than in the pre-EORE FGD. In three out of seven of these villages, there were incidents of community members engaging in risky behavior despite having received EORE. In one notable incident, a local pastor who had received EORE was ploughing a field with a group of young men who had not received EORE when they encountered an item of unexploded ordnance (UXO). Instead of sharing key safety messages and warning them to not touch the item, the pastor played with the EO, throwing it to the other men he was with, as was reported in one FGD. The remaining communities have a lower score in the post-EORE FGDs, not because the communities are behaving in a more unsafe way since they attended an EORE session but rather because the participants were not forthcoming in discussing risky behavior when MAG Community Liaison teams conducted the pre-EORE FGD. A key lesson learned is that the data gathered in the first FGD might not always be fully representative due to initial lack of trust. However, the FGD process was invaluable in building relationships with the local communities, particularly in highly-militarized villages,[11] and communities often participated more freely in the post-EORE FGDs. Being able to directly address what the participants have been told in the FGDs helps to make future EORE more tailored and hopefully for the messages to sink in more. The process of having a discussion makes the community address the challenges together and understand whether they have different beliefs about what to do. This is helpful because if unsafe practices are identified, then the elders can specifically take ownership over not allowing this to happen in the future.

In **Somaliland**, seven out of the eight communities who have participated in both a pre-/post-EORE FGD conducted by HALO have reported positive behavior change, with only one exhibiting no change in behavior. This particular community who did not exhibit more

FGD conducted by NPA in the village of Kimunza Nzadi, Angola.
Photo courtesy of NPA.

positive behavior following EORE continued to report identified EO and spread awareness as they had done previously but struggled to convey key messages to nomadic populations. Further, while the FGD methodology can build trust in certain communities, it can also have the opposite effect in some contexts where communities exhibit survey fatigue. In some communities in Somaliland, people have been waiting for clearance for almost twenty years and are frustrated that clearance has not yet started in their community.

There are several FGDs that HALO in Somaliland did not end up using for analysis because (*a*) the data was insufficient or (*b*) biased answers or leading questions were suspected. In these instances, the information is still used for qualitative purposes and future EORE project design, but the statistics are not included when reporting on the outcome indicator. As this methodology takes a lot more time than other types of M&E methods due to the nuance required, it is important that all operators conduct continual monitoring and quality assurance of the COTs to ensure that high-quality qualitative information is being collected for FGDs or confirm that the information is unusable for scoring.

Overall, the FGD methodology in Somaliland has proven to be hugely successful. The notes produced from the FGDs illustrate that communities have exhibited greater awareness of behavior towards EO among community members, and that conducting the FGDs allows COTs to stay a bit longer, build trust, and has resulted in more people reporting items found or stockpiled at home. While the primary objective of the FGDs is to understand behavior change, they have proved to be great centers of debate, and provide the COTs with valuable, contextual information, which has then been used to tailor future EORE sessions to specific groups and where it is most needed.

In **Cambodia**, HALO has conducted 20 complete pre-/post-EORE FGDs of which eleven communities have reported increased safer behavior. The challenge with ongoing EORE in Cambodia is that much like other legacy contamination countries, it is understood that behaviors may not have changed for many years as some have adapted over time to risky or forced behavior because of the lack of alternative options to livelihoods.

In **Zimbabwe**, NPA is working mainly along the border with Mozambique. The mines emplaced along this border impede the

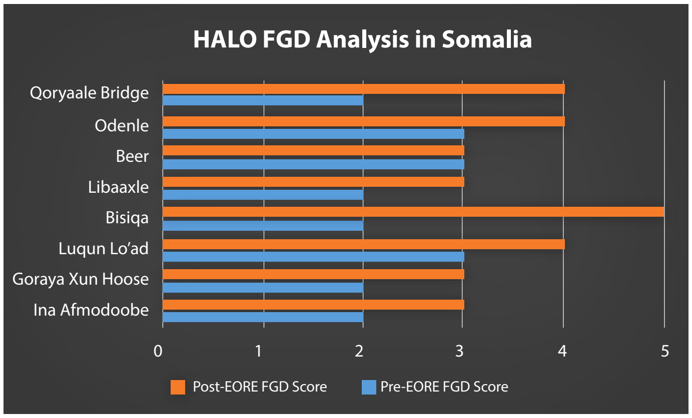

Figure 1. HALO FGD Analysis in Somalia.

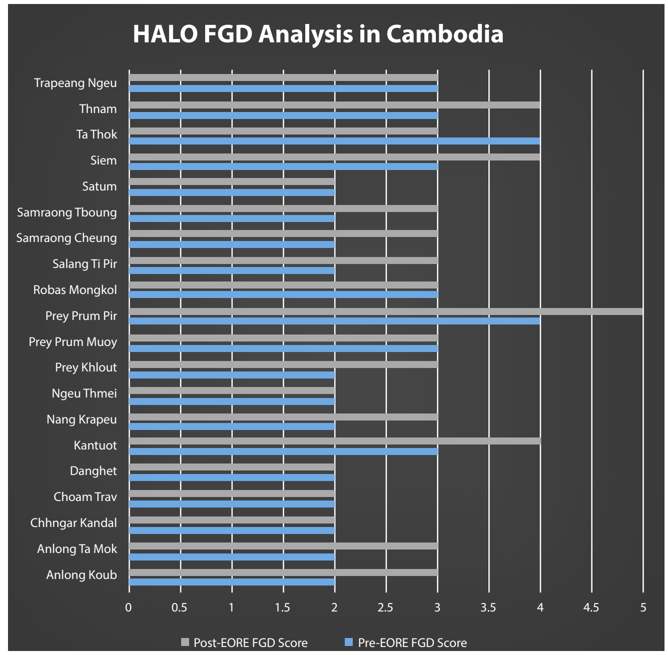

Figure 2. HALO FGD Analysis in Cambodia.

access of small scale and commercial farmers as well as timber companies to manage forestry.

NPA has applied the FGD methodology since 2018 with guarded success. The FGDs have provided NPA with valuable information for understanding the differences in vulnerability, roles, and needs of the respective age groups, sex, and traits in the communities, allowing the program to improve planning and EORE quality accordingly.

Despite the benefits of the approach, NPA has experienced a number of challenges in the implementation. Large parts of the population are seasonal workers, which makes it difficult to keep track of the same group of people for between three and six months for the post EORE FGD. In addition, working adults have shown limited interest in dedicating the required time for FGDs, making it difficult to ensure representational participation.

As for the actual discussions, NPA occasionally experienced that the community provided COTs with the "correct answers" while continuing to practice unsafe behavior, e.g., cultivating crops in contaminated areas for economic reasons. Thus, the method requires the building of sufficient trust to ensure the community is open to talk about its needs and reasons for undertaking unsafe behavior. Follow-up visits to contaminated areas to verify that the community follows its own stated behavior may be an option to validate FGD findings.

Such cases illustrate yet again that the mine action sector needs to work closely with other sectors, i.e., development NGOs, authorities, etc., in order to ensure positive behavior change by offering people something beyond mere advice on safer behavior. Structural causes must be understood and addressed. As such, it is important to take note of the lack of fully honest answers and stated answers versus actual behavior change. NPA also noted that the rigidity of the scoring did not allow for the program to report on subtle changes in stated behavior resulting from the EORE sessions. As illustrated in Figure 3, three out of seven communities showed positive changes in pre-/post-EORE sessions. The program highlighted that even though the level of understanding of the threat was raised, a majority of people within the community continued to undertake unsafe, forced behavior, leaving the score unchanged. Thus, without proper explanation, the statistics will convey a somewhat incomplete picture of the impact. However, this is only a reporting issue. The FGD clearly showed that the program would have to link in with other sectors to properly address the forced unsafe behavior as EORE in itself would not be a sufficient measure. Broader reach of the FGDs, or discussions jointly undertaken with other sectors could lead to a better understanding of the keys to change behavior.

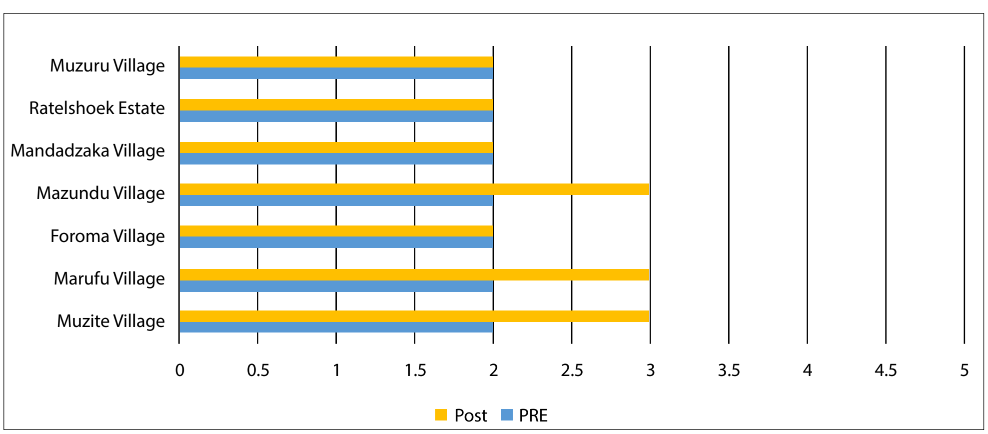

Figure 3. NPA FGD Analysis in Zimbabwe.

EO RISK EDUCATION AND EO RISK REDUCTION

People opt for dangerous behavior when they see no other choice. For example, when sourcing drinking water, gathering firewood, or finding areas for hunting, these may only be reached by passing through a minefield, thereby knowingly putting their lives at risk to sustain their livelihoods. Children may not know or simply forget safe behavior; for instance when they stray playing hide and seek, but this is something that can be more easily addressed through EORE and attention from well-informed parents, siblings, and friends.

Some groups, like ex-combatants and those designated as "village deminers" will often deliberately, recklessly take very high risks to enter hazardous areas to remove EO. They do this to support other villagers or to make a bit of money. Farmers and shepherds come across numerous items of EO in certain countries. Often, they decide to move the items themselves, motivated by protecting their children or their livestock. Why do they not report these EO items to the local authorities instead of putting themselves at risk? Perhaps because the response takes too long, or out of fear of reprisal. FGDs help to find answers to these questions and to explore more relevant and realistic suggestions to behavior change—suggestions that are community-driven and context specific.

Other behavior proves even more challenging to address. For example when people keep EO with a profit motive in mind: children in Laos have sold cluster munitions so they have money to buy ice cream; to harvest explosives for blast fishing (a very destructive practice for the environment)[12] or to blow up stones/rocks; to harvest high-value metals from EO; or simply to use EO as construction material. How can we reduce the risks by persons who are either forced to continue this behavior or see no reason why they should stop their reckless behavior, often putting bystanders including family members at unacceptable risk?

Effective risk reduction[13] must go beyond "just" EORE and should include options for safer alternatives to livelihoods in affected communities. For example, a safe playground may be built to reduce children playing in unsafe areas, firewood as fuel can be reduced by 50 percent when using fuel-saving stoves, and drilling a borehole may stop people from going through the minefield to the river to collect water. These alternative projects may be best placed in certain communities while inappropriate in others, so context is key. Some mine action operators may not have capacity to implement these projects directly, so partnering with wider relief and development organizations may be essential. For the post-EORE FGD we added a question on why some behavior did change or did not change for this exact reason.

CONCLUSION

Using FGDs to measure behavior change has worked but has its limits when applied within a short timeframe of three-to-six months after an intervention. Sustained behavior change will only manifest itself over time and, therefore, must be planned and implemented beyond any donor funding cycle.

The Oslo Action Plan, agreed upon at the fourth review conference of the *Anti-Personnel Mine Ban Convention* in November 2019, aims to steer the mine action community for the coming five years. It calls for risk reduction in the context of EORE:

Action point 28: "Integrate mine risk education activities with wider humanitarian, development, protection and education efforts, as well as with ongoing survey, clearance and victim assistance activities to reduce the risk to the affected population and decrease their need for risk-taking."[14]

Action point 30: "Prioritise people most at risk by linking mine risk education and reduction programmes and messages directly to an analysis of available casualty and contamination data, an understanding of the affected population's behaviour, risk pattern and coping mechanisms, and, wherever possible, anticipated population movements."

As highlighted previously, implementing risk reduction projects will often be beyond the scope of mine action itself and require an integrated approach. FGDs, as presented in this article, allow operators to gain a better, context-specific understanding of affected community's needs as it relates to risk reduction. The population understands better who we are, why we are there, and what we can offer. As operators, we can use the information gathered from the FGDs to improve our work by refining targeting, messaging, and identifying risk reduction alternatives.

See endnotes page 68

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29

DETONATING THE MEDIA

RAISING THE PROFILE OF MINE ACTION

By Paul McCann [The HALO Trust]

Prince Harry (right) walks down a street in Huambo built on cleared ground from minefield H013, visited by Princess Diana in 1997 (left).
All images courtesy of The HALO Trust.

In January 1997, Diana, Princess of Wales, travelled to Angola with the International Committee of the Red Cross (ICRC). She did not travel alone. Around ninety international journalists and a number of TV crews accompanied her. It is unlikely that Angola's sleepy second city of Huambo saw similar numbers of press until September 2019, when her son, Prince Harry, Duke of Sussex, walked in her footsteps.

The two visits, separated by twenty-two years, produced arguably the greatest amount of media attention ever achieved by humanitarian mine action (HMA). Comparable with the *Anti-Personnel Mine Ban Convention* (APMBC) conference in December 1997, such exposure is considered an unambiguous good. But how can mine clearance organizations and others harness this publicity to benefit HMA? How do you keep mine action in the public eye when such high-profile visits are over? And what issues do HMA organizations need to bear in mind when they seek public awareness for their work?

Princess Diana had been a patron of the British Red Cross since the early 1980s, and before 1997, had made foreign visits for the ICRC to Nepal and Zimbabwe on non-landmine related issues. In 1995, the ICRC launched its public campaign: Landmines must be stopped. The veteran British journalist Bill Deedes and Director General of the Red Cross Mike Whitlam were among those who brought the issue of landmines to Princess Diana's attention. The ICRC considered taking Diana to Cambodia, Bosnia and Herzegovina,[1] or Vietnam, but Angola was ultimately selected to highlight the danger of landmines to civilians.[2]

In 1997, the Lusaka Protocols had produced a fragile pause[3] in the country's long civil war, but the country remained a war zone. Significantly, Angola's landmine contamination was among the worst in the world. The full number of landmine casualties in Angola is unknown, with some estimates reaching upwards of 88,000 people.[4]

Diana's visit to Angola included trips to rehabilitation clinics with the ICRC in Luanda and Huambo. In Luanda, she was pictured by the press with a young girl, Sandra Tgica, on her lap. Sandra was a landmine survivor who had lost her leg. Diana's visit was not uncontroversial, and she was denounced as a "loose cannon" by a minister in the UK government. That condemnation only served to generate more news interest in the visit and made it increasingly political in tone. The main opposition party in the UK meanwhile publicized its policy of supporting a mine ban. The most iconic pictures from the Angola trip were taken when the most famous woman in the world donned a protective apron and visor and walked into a Huambo minefield.

The San Antonio district of Huambo, to the southwest of the main square, was then known as the *Barrio Militar* because of the presence of several army bases—including a logistics base on what is now *Ave. 28 de Maio,* and a nearby large Cuban base. The presence of these military positions meant there were extensive minefields in the area. Huambo itself had changed hands during the conflict and had occasionally been under siege.

The minefield visited by Princess Diana in January 1997 was named H013 by The HALO Trust (HALO), which first began clearing mines in Angola in late 1994. The minefield had been laid to protect a military supply depot known as the *Regimento de Abastecimento Militar* or "RAM." Heavy metal contamination meant HALO's detectors struggled to isolate landmine signals and complete excavation, and clearance of the entire minefield was a slow and painstaking process.

The night before the 1997 visit, Paul Heslop, then HALO's Angola program manager, and now Chief, Programme Planning & Management at the United Nations Mine Action Service (UNMAS), had a staff member cut up one of his pillow cases and draw the HALO logo on it in pen so it could be stitched onto the Princess's body armor. During the visit she blew up a mine and when requested to repeat her walk through H013 by photographers who had missed the shot, she complied.

The photographs and footage of Diana in Huambo were front-page news and lead items on news bulletins around the world. In the aftermath of her sudden death seven months later, it became one of the most prominent images used to illustrate her life of campaigns and compassion. The body armor worn by Diana in Huambo is now in the collection of the Royal Armouries Museum[5] in Leeds

Prince Harry launches the Landmine Free 2025 Campaign in April 2017.

31

A HALO vehicle crosses difficult terrain in order to access remote minefields in Angola.

in Northern England. To this day, HALO staff simply mention the iconic image of Diana wearing body armor as a cue to remind people what HALO does.

Princess Diana's involvement with landmines has been credited with helping secure the adoption of the APMBC—the most widely observed arms control treaty in history. In many ways, this is the ultimate example of a humanitarian or development issue harnessing its moment in the public eye.

For HALO, then a lean and relatively small, publicity-shy organization, the famous photographs of Princess Diana with a pillow case logo, give it global brand exposure. The recognition was such that HALO got by without hiring a dedicated communications team until well into the 21st century.

Prince Harry continued his mother's advocacy work on landmines, but initially with a lower level of public profile. In 2010 and 2013, he visited minefields in Mozambique and Angola with HALO. However, both visits were largely private, with images and footage released to the media afterwards. On the 20th anniversary of the APMBC and of his mother's Angola trip, HALO and Mines Advisory Group (MAG) approached Prince Harry to mark the anniversaries with a public event in London on International Mines Awareness Day, 4 April 2017. Before an audience of donors, supporters, ambassadors, and campaigners, the Duke movingly invoked his mother's memory in a speech that was widely carried by media outlets in the US, UK, and Europe. At the same event, the UK government's Department for International Development announced £100 million ($124 million) of funding for its Global Mine Action Programme.

The April 2017 event was hosted under the banner of the Landmine Free 2025 Campaign. Such was its success in garnering mainstream and social media traction that what began as an isolated event has grown to become a global advocacy campaign.[6] The Campaign's goal is to re-energize global support for landmine clearance and ensure as many countries as possible are landmine free by 2025. Currently, only 0.4 percent of overseas development assistance (ODA) is spent on clearing landmines.[7] The campaign is calling for a fair share commitment of 0.7 percent of ODA, which would be a game changer for the sector in reaching a mine free world.

Chris Ship recording coverage for ITV.

The work that international NGOs do for development and post-conflict issues is not always an easy story to sell. Media travel budgets and foreign news coverage have declined, and audiences cannot always empathize with the plight of people far away. The involvement of Princess Diana and her son has always made HALO's approach to journalists easier, certainly in the UK. A recognizable face or name gives journalists a shorthand way into a story. That is why so many international organizations and NGOs turn to celebrity ambassadors to help reach both media and audiences.

In 2019, the Angolan government decided it wanted to develop the economy of the southern Cuando Cubango Province, one of its most remote

Prince Harry and Valdemar Fernandes in Huambo.

regions, by attracting and protecting wildlife. However, the minefields littering the province needed to be cleared first in order to ensure people's safety and to enable wildlife protection measures. Thanks to Angolan government funding, HALO will begin clearing the mines in two national parks. However, there are dangerous minefields across the region, especially in the wider watershed that feeds the Okavango Delta in neighboring Botswana. Clearance of the mines is a key component in the protection of the Kavango–Zambezi Transfrontier Conservation Area, Africa's largest wildlife protection initiative.

In June 2019, Prince Harry agreed to speak at a Chatham House meeting on clearing landmines in the Angolan watershed. Shortly afterwards, Buckingham Palace announced that the Prince would visit minefields in Angola during a September 2019 tour of Africa. Both the Chatham House event and the Africa tour announcement attracted widespread media coverage.

To demonstrate the need for clearance in the Okavango watershed, HALO set up a demining camp and tents for the media, its royal guest, and other dignitaries near Dirico in the far south of Angola. Moving supplies for the camps required repeated road trips, each of which took five days because of the deep sand and lack of roads in the area. Mined roads had to be avoided. Crocodiles and hippos watched from the rivers as HALO set up camp in one of the continent's last remaining wildernesses.

On the morning of 27 September 2019, Prince Harry walked into minefield HKK220 in the Luengue-Luiana National Park near Dirico at 6:30 a.m. He was accompanied by HALO regional manager José António, who had accompanied him on his previous Angola visit. Behind them were a selection of travelling journalists who were flying with the Prince on his African tour and representatives from the Angolan media. Minefields are no place for massed ranks of photographers stepping backward for a better angle. HALO had repeatedly rehearsed the minefield visit, taking sightlines into account, the angle of the sun at 6:30 a.m., and the safety of all concerned. After leaving the minefield, the Prince detonated a mine and made a short speech in which he described mines as an "unhealed scar of war." Much of this was broadcast live on British television.

The Prince was then flown, followed by the media, 800 km north to Huambo, where he was escorted to what once had been minefield H013, visited by his mother over twenty years ago yet is now the bustling *Ave 28 de Maio*. Within the area of the old minefield, there are now two completed colleges with a third under construction, a small furniture factory, homes, and shops. The most-photographed minefield in the world is a fine example of the development that can take place once landmines are removed.

The Prince was escorted by Valdemar Fernandes, who had been clearing a nearby minefield when the Prince's mother visited in 1997.

33

One of HALO Angola's all-women teams of deminers prepares for work.

He also met hundreds of schoolchildren who had no idea the area had once been lethal. The third leg of the busy day was a reception at the British Embassy in Luanda, where Sandra Tgica, the landmine survivor who as a young girl met Princess Diana twenty years earlier, was one of the guests.

Ensuring that the celebrity of the visitor does not take precedence over the issue itself is a challenge with high-profile visits. To combat this, visiting journalists were sent on prearranged visits to Angolan minefields, so that documentaries could be aired on ITV in the UK and on CNN and ABC in the United States. Feature writers spent the night in camps with women deminers in another part of Angola. Interviews were set up with landmine victims injured by the minefields in Huambo. The aim was to expand what could have remained a royal story into one with a wider focus on landmines and their pernicious effect on ordinary people's lives. As a result, a wide array of stories emerged after the visits. As expected, Prince Harry remained the draw, but audiences also learned about deminers, survivors, and the major impact of contamination on communities across Angola.

Both the Dirico and Huambo visits earned tens of thousands of media "hits" around the globe on mainstream and social media. HALO's website received 3,500 percent more visitors than on a normal day in September.

Following the visit was the challenge of sustaining momentum. With the issue of landmines in Southern Africa fresh in the minds of many, a UK-wide fundraising campaign was kicked off in conjunction with the UK government's Aid Match scheme. The campaign, Breaking Boundaries, focused on raising funds for mine clearance in Zimbabwe. Again, celebrity engagement generated considerable media attention. Newspapers could cover the campaign using images of Prince Harry in a HALO-branded shirt. In this way, HALO was able to use Prince Harry's work in Angola to generate interest and engagement to support landmine clearance in another country that faces similar challenges.

The involvement of Princess Diana and her son has benefitted the wider landmine cause and given HALO greater brand awareness than many similar-sized organizations. Such a profile does carry risk, as any journalist looking for a story on HALO has a better chance of getting it published by adding "Harry Charity" and a picture of the Prince in body armor to their piece. Similarly, any high-profile supporter is likely to have varying levels of engagement at different times. All charities with celebrity supporters have to learn to manage both with and without the attention such celebrities bring.

In seeking to boost their public profile by a high-profile supporter, HMA organizations, like any other non-profit, need to be wary of being eclipsed by the celebrity of their patron. In Angola, HALO constantly endeavored to put landmine survivors, hard-working deminers, and all beneficiaries of mine action firmly into the ambit of the media.

In 1997, a royal visit and dozens of journalists effectively fell into HALO's lap. In 2019, months of work, planning, and a herculean logistics effort in a remote part of Africa was needed to pull off a similar level of exposure. By focusing on landmine clearance, beneficiaries, and the transformation that takes place when mines are cleared, HALO was able to get its message through amid the cacophony of cameras.

See endnotes page 69

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Paul McCann has been head of communications at The HALO Trust since 2016. He previously worked as a spokesman for the United Nations in the Middle East and was a journalist for *The Times*.

A NEW APPROACH TO UNDERSTANDING, ACHIEVING, AND DEMONSTRATING IMAS COMPLIANCE

By David Hewitson [Fenix Insight Ltd.]

Mine action organizations routinely state that they are "IMAS compliant," but it isn't clear exactly what that means, how anyone knows with confidence whether they are compliant or not, or who is authorized to make such statements. This article draws on recent work by Fenix Insight Ltd. to database the requirements and recommendations found in IMAS, setting out a rigorous, evidence-based approach to answering key questions about the compliance status of mine action organizations. It suggests methods for determining which requirements are relevant to which organizations, what different levels of compliance there might be, and how to integrate compliance checking into established approaches to tendering, accreditation, and organizational monitoring processes. The article describes the freely available Fenix IMAS compliance database tool.

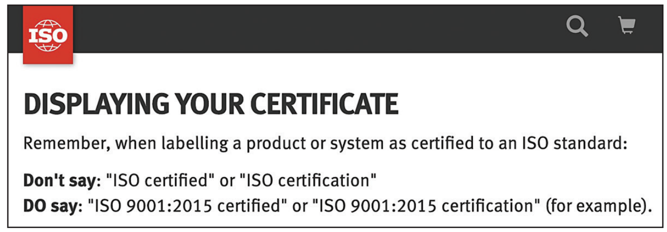
WHAT IS IMAS COMPLIANCE?

Mine action organizations (MAOs) like to say "we're IMAS compliant," but what does that mean, how does anyone know for sure, and is it appropriate for organizations to "self-declare" on such a significant matter? The question is one that may sometimes be addressed within the narrow confines of a specific activity, but to a great extent the sector has chosen to set the question to one side.

The reality is that no organization, whether national authority, mine action center (MAC), or operator needs to satisfy every requirement in IMAS. Some requirements are clearly focused on specific levels of actors, such as the responsibilities of a national mine action authority (NMAA), while others relate to activities that some organizations don't engage in (programs that do not use animal detection systems need not seek to comply with those IMAS).

There is also the fundamental question of what constitutes a requirement in IMAS. Each IMAS includes an explanation of how the words *shall, should,* and *may* are used. Shall indicates "requirements, methods or specifications which are to be applied in order to conform to the standard." Should indicates "the preferred requirements, methods or specifications." May indicates "a possible method or course of action." The language suggests that only shall statements must be complied with in order to "conform to the standard." Should statements are preferred, but as such appear to constitute recommendations. In quality management terms, a failure to satisfy a shall statement would represent a nonconformity, but the status of a failure to satisfy a should statement is less clear.[1]

Extracting a concise set of applicable requirements and recommendations from the substantial body of documentation that is IMAS is difficult to do. That difficulty brings uncertainty among operators, monitors, accreditors, clients, and authorities as to exactly what IMAS compliance means.



WHAT DOES COMPLIANCE MEAN IN OTHER STANDARDS REGIMES?

The IMAS system has always sought to reflect the principles, approaches, and the language found in the International Organization for Standardization (ISO) system. The first thing to note is that no one says "we're ISO compliant." Instead they are more likely to say we are "ISO-9001 certified," or "we are an ISO 14001 organization." The question of ISO compliance is one that focuses on specific standards rather than the generality of the overall system—not surprising when ISO has published 23,098 standards to date focusing on specific industries including food safety, agriculture, and technology as well as the widely applicable quality, environmental, and safety management standards that are more familiar to the mine action sector.[2]

The ISO approach to confirming compliance consists of three operational levels. The main burden of determining compliance is placed upon those organizations seeking to gain and maintain certification against the various standards.[3] Internal auditing processes, applied by the certified organizations themselves, are central to concepts of ISO compliance. The next tier of compliance management comes with the certification bodies: the organizations that have been accredited to inspect and monitor applicant organizations and issue certificates of compliance. In addition to conducting standard-specific certification and recertification inspections (every three years), certifying bodies also engage in ongoing compliance monitoring through annual surveillance inspections. Above the certification bodies lie the accreditation bodies, of which there is only one per ISO member country.[4] The accreditation bodies confirm the competence of the certification bodies.

Many MAOs have chosen to adopt ISO standards: most commonly ISO 9001 (the quality management systems standard) but increasingly ISO 14001 (for environmental management systems) and ISO 45001 (for occupational health and safety management systems). As such they will have engaged a certification body to inspect their system and check for evidence that it is being applied. Most MAOs do not need to have direct contact with an ISO accreditation body.

SIMILARITIES AND DIFFERENCES

There are parallels and some important differences between the ISO approach to compliance and that associated with IMAS. The

Figure 1. Direction on communicating ISO certification status (including the applicable edition of the standard).
Figure courtesy of www.iso.org/certification.

35

most obvious potential parallel is that of *standard-specific compliance*. Different mine action actors engage in different activities. It makes sense for them to seek and declare compliance with only those parts of the IMAS system that are directly relevant to what they do.

One important difference between an IMAS and an ISO-standard is that an organization typically adopts an ISO standard in its entirety. Different elements of the standard demand different responses from different parts of the organization (such as senior management, designers, workers, etc.), but the whole standard applies to the organization using it. An IMAS is different, imposing different requirements on different organizations, such as NMAAs, MACs, MAOs, and occasionally specialist function providers such as monitors. With an ISO standard, an organization knows it must embrace the standard entirely, even if it needs to think about implications for different parts of its own structures. When a mine action actor seeks to adopt an IMAS it must first disentangle which parts are applicable to its own roles and responsibilities.

There are also similarities and differences in the use of language to communicate the *degree of compliance*. Both IMAS and ISOs identify important verbal forms and describe how they are to be interpreted; ISO identifies the following:

- shall indicates a requirement[5]
- should indicates a recommendation[6]
- may indicates a permission
- can indicates a possibility or a capability[7]

ISO documents almost exclusively use shall within the main body of *normative* text found in standards. Should is generally confined to informative annexes or guidance documents.[8] IMAS adopts a similar terminology structure (although without the use of can), but it contains a greater mix of shall and should statements than is the case in comparable ISO documents.[9]

While there is no doubt that any organization seeking to comply with IMAS must satisfy every shall statement, the status of should statements is not quite so clear, but it is reasonable to expect that any organization serious about its professional commitment, performance, and reputation would embrace should statements as well. The role of may is sometimes also uncertain, primarily because it often appears in IMAS with its other English-language meaning of "possibility" rather than

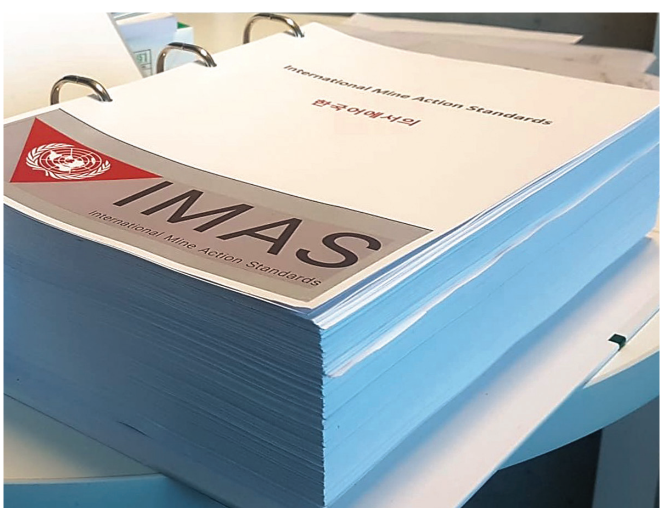


Figure 2. The scale of the task: IMAS in full, printed out in hard copy.
Figure courtesy of the author.

"permission." Similarly, there are occasions when words and phrases such as "must" or "it is required that" are used in IMAS strongly implying a shall statement without explicitly using the word shall.

The other important parallel is the emphasis on a rolling program of self-assessment as the core method for an organization to maintain compliance. External checking (whether by an ISO certification body or a mine action monitoring agency) plays its part, but its primary role is to confirm that internal compliance management is comprehensive, rigorous, and effective.

IMAS also includes a more substantial body of background explanations, guidance, educational material, and advice than is found in the ISO system. ISO tends to separate standards that only contain specific requirements from supporting or guidance documents, which provide advice on how to satisfy those standards.[10]

A "FILTERED" APPROACH TO IMAS COMPLIANCE

Bringing confidence to operators, monitors, and authorities about IMAS compliance requires the ability to apply the different "filters" described previously:

- filtering by activity, only selecting those standards that are relevant to the organization's activities
- filtering by "'stakeholder," identifying only those aspects of the relevant IMAS that are applicable to the roles and responsibilities of the organizations
- identifying the degree of compliance that the organization wishes to assess against, i.e., "shall" requirements alone, or "should" recommendations and "may" permissions as well?

The first step in the filtering process is relatively easy. A review of the list of applicable IMAS allows an organization's managers to identify those that are relevant, although even here bringing a more considered approach to the idea of standard-specific compliance may raise questions within some organizations. Many MAOs will identify the core operational IMAS—surrounding practical survey and clearance work—as being relevant to what they do. Most will also wish to show that they comply with the standards relating to quality, safety, and environmental management. It is not so clear whether MAOs will also feel it necessary to demonstrate compliance with some of the supporting standards. By thoroughly considering the actual requirements of different IMAS afresh, organizations will be able to more carefully decide with which standards they will declare compliance.

The other two filtering steps (stakeholder level and degree of compliance) are harder to complete. Extracting only those requirements that are relevant to a specific level of stakeholder can be done but is a burdensome task. Similarly, identifying different levels of compliance requires searches within each standard, a process that may be necessary to do again whenever the range of activities an organization engages in changes.

DATABASING IMAS

To make the process of filtering relevant requirements and recommendations easier, Fenix has incorporated normative elements of IMAS into a database available for free at www.mineaction.net.

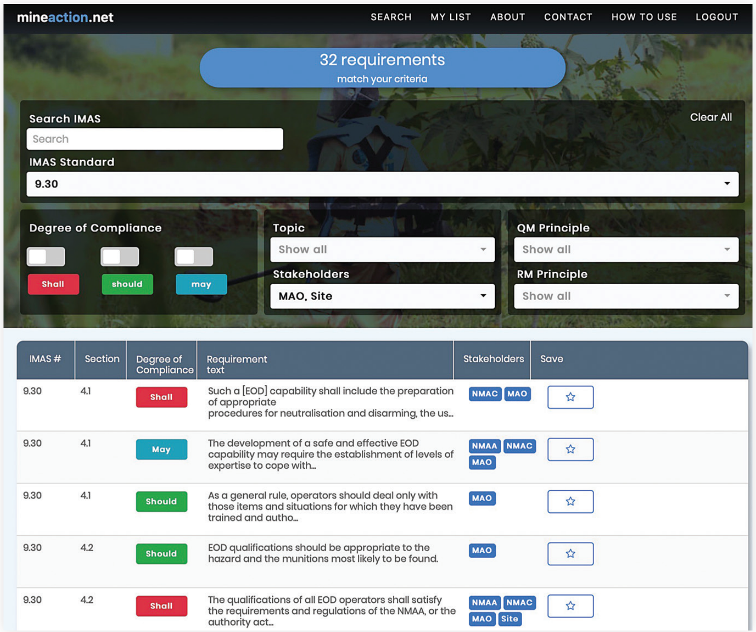


Figure 3. Mineaction.net main search page filtered for one IMAS and two stakeholder options.
Figure courtesy of the author.

The result is a simple tool that can be used in multiple ways. The database was designed to make it easy to develop focused checklists that allow mine action managers to identify only those requirements and recommendations specifically applicable to their own organization's activities, roles, and responsibilities. The extensive, hard-to-define, and often uncertain topic of "IMAS compliance" is turned into bite-sized chunks that contain only the specific text extracts relating to compliance.

Targeted checklists help managers assess their own organization or project's degree of compliance quickly and comprehensively. However, checklists are also intended to make it easier for monitors, whether internal or external, to include questions of IMAS compliance in their ongoing inspection schedules. Possible extensions of the same applications to accreditation and contracting processes are clear and have already been identified by larger potential institutional users and national authorities.

The database approach also allows a user to select a keyword, search the system, identify relevant entries in IMAS, and then do so again seconds later for another topic of immediate interest or importance. Users can approach the entirety of IMAS on a cross-cutting basis from a thematic perspective. This system has transformed early users' ability to interact with IMAS. During meetings, questions along the lines of "what does IMAS say about…" can now be answered immediately and follow-on questions about other topics can be addressed just as quickly.

Making it easier to engage with IMAS in practical terms may encourage authorities, operators, and clients to define more clearly what they mean by IMAS compliance and what they expect from those organizations that wish or are required to demonstrate compliance.

The database is just a tool, albeit a useful tool. As such it has limitations. Firstly, it only contains normative text, so none of the explanatory or advisory information that makes up much of the material in IMAS is included.[11] Secondly, the system does not provide any guidance (at least at this stage) on how to demonstrate compliance.

That means this tool is not a substitute for the documented standards themselves, available through the IMAS website at www.mineaction-standards.org. It is still important that anyone serious about compliance with IMAS have some familiarity with the full body of relevant text. Similarly, the range of publications and training packages offered by the Geneva International Centre for Humanitarian Demining and other institutions, addressing the expectations and meanings of core concepts in IMAS, remain as important as ever. This simple tool can potentially transform the way that mine action actors engage with, understand, and demonstrate compliance with IMAS.

WHERE NEXT?

The mineaction.net team is already looking into bringing other material into the system. Obvious candidates include IMAS in other languages (one possible project is already under consideration), National Mine Action Standards (NMAS), Technical Notes for Mine Action (TNMA), and relevant parts of the informative Annexes in IMAS.[12] Selected standards from the International Ammunition Technical Guidelines (IATGs), which use the same language of *shall*, *should*, and *may* have already been incorporated into the database to investigate any adjustments that may be necessary to accommodate them. Further investigation is under way into the potential benefits of adopting a similar databasing approach to the main instruments of international humanitarian law that apply to the mine action sector.

The team is also working to extend the compliance management functionality available through the site to include (1) the ability to save and maintain multiple check lists, e.g., for different country programs, projects, and contracts; (2) list sharing, i.e., so that checklist "owners" can share selected lists with monitors, accreditors, authorities, clients, donors, and other members of their own teams; (3) documentation of compliance evidence; and (4) the idea of "smart updates" when users would be automatically notified whenever changes in new editions or amendments to an IMAS affect any of their saved compliance check lists. Fenix hopes to be able to make these additional features available later this year.

See endnotes page 69

David Hewitson
Fenix Insight Ltd.

David Hewitson has been working in mine action for almost thirty years. He conducted practical clearance of landmines in Afghanistan, Angola, Cambodia, and Mozambique establishing and managing field programs. In 1995, he founded a commercial demining company and employed more than 3,000 people in projects all over the world. He was an early adopter of the ISO 9000 quality management system and has driven implementation of associated environmental and safety management standards. He has drafted IMAS for Land Release, Non-technical and Technical Survey, Quality Management, and Risk Management and Monitoring of mine action organizations. As a director of Fenix, he engages in technical field operations as well as wider governmental and institutional advisory work. Before joining the mine action sector, he served in surface ships and submarines in the Royal Navy. He has a degree in Aeronautical and Astronautical Engineering.

37

THE LETHALITY INDEX:

RE-CONCEPTUALIZING IED CLEARANCE PLANNING AND DELIVERY IN IRAQ

By Mark Wilkinson, Ph.D. [United Nations Mine Action Service Iraq]

Explosive hazard (EH) clearance comes at a cost and, logically, with accountability expected as a quid pro quo both for those conducting and those funding clearance activities.[1]

Today's accountability problem arguably begins with the recognition that EH clearance, particularly in complex environments contaminated with improvised explosive devices (IEDs), differs radically from conventional mine action operations of the past, introducing various new factors that influence costs and cost-effectiveness. This, in turn, begs two questions: "What factors?" and "How are they measured?"

Hence, before the mine action community can evaluate cost-effectiveness leading to accountability, it must first re-conceptualize clearance itself based on well-documented, current clearance operations such as derived from the UNMAS experience in Iraq.

Traditional metrics for the measurement of EH generally utilize the relationship between square meters of land cleared and items of EH removed/rendered safe in the process, irrespective of other factors. The exclusion of these other factors understates both the complexity of the clearance problem itself as well as the associated factors that drive costs. This article looks at additional factors, suggesting how the sector might determine their relative value in the scheme of EH clearance costs.

FACTORS. Based on experience in Iraq, clearance arguably is a function of six factors, each contributing to a cost matrix: (1) events leading to contamination; (2) extent of contamination; (3) environment type; (4) exposure of operators based on device and/or its design; (5) experience such as skills and assets appropriate for clearance and safe removal of threats as assessed; and, given that ISIS elements continue to engage in asymmetric attacks on both civilians and security forces throughout Iraq's so-called liberated areas, (6) disruption that adds delay to the cost of operations. The common denominator across the matrix is the contribution of each factor to time-on-task for those clearance assets deployed.

EVENTS. Given that the mix, amount, location, and concentration of EH in contaminated areas correspond with conflict phases, "informed" non-technical surveys (iNTS) as currently conducted by UNMAS Iraq effectively "look back in time" to data collected on design, manufacture, and deployment of weapons consistent with conventional and non-conventional combat tactics, and documentation of hostilities, concluding with the present, on-going insurgency.[2,3] With this in-depth study of the pre-, event, and post-event phases of conflict as a guide, UNMAS Iraq works toward an initial "best estimate" of threat environments by preparing for clearance tasks and required skill sets and mechanical assets.

EXTENT. Despite the progress made in removing EH from areas liberated from ISIS after 2017,[4] Iraq still remains one of the world's most contaminated countries by area[5,6,7] based on its more than 2,500 square kilometers of contaminated land. To place this in perspective, the International Campaign to Ban Landmines classifies contamination in excess of 100 square kilometers as "massive."[8] Add on to this estimate the fact that an estimated 130,000 residential homes in liberated areas are reported as damaged or destroyed,[9] and many of these are assessed as likely to contain explosive remnants of war (ERW) or IEDs and the true scale of the problem is immense.[10] Further, the overall impact of the level of EH contamination across all economic sectors has yet to be measured. For example, in Ninewa Governate alone, of a total of 100 confirmed and suspected hazardous areas (SHA) identified in al-Hamdaniya, Baashiqa, and Tilkaif districts, the majority of SHAs were located in agricultural areas.[11] As of 2019, agricultural capacity, the second most important sector of the Iraqi economy after oil, remains down 40 percent from pre-ISIS levels.[12]

ENVIRONMENT. Within Iraq's recorded contaminated areas, two types of environments bracket the clearance landscape extremes. The first concerns the comparatively simple rural environment defined by predictability and consistency. These can comprise IEDs of similar design laid in linear patterns with even spacing to defend a position from an assault, either surface or sub-surface, in open land typically visible to the naked eye, easily detected with standard gear, and often free from unexploded ordnance (UXO), other battle debris, and scrap metal.[13] Conversely, the second involves the highly-complex urban environment defined by ingenuity and random occurrence. Complex environments include a diverse range of IEDs of varied and innovative designs, well-concealed with a vertical dimension added, combined with high concentrations of UXO, often mixed with debris and within collapsed buildings that limit access and maneuverability.[14]

EXPOSURE. As with the two types of environments, hazards removed and rendered safe in each suggest comparatively low and high exposure threat levels for operators based on factors such as device type, design, condition, amount, as well as potential biological and chemical hazards. In simple environments, variants of a single type of crudely but effectively designed, victim-operated IED (VOIED) predominate, making clearance repetitive. These VOIEDs consist of a 6-10 kg main charge connected by a detonating cord to one or more high-metal pressure plates, and are occasionally fitted with anti-lift devices, a 9-volt battery, and a commercially manufactured electrical detonator.[15] This simple environment reduces the exposure threat to a comparatively

A Local National Search team clears empty .50 caliber cartridge cases from an area inside the al-Shifa Hospital Complex in West Mosul. This is a 'Complex 3 Dimensional Urban Environment.' Even simple activities like this require a high level of training and oversight to ensure safe conduct and delivery.
Image courtesy of UNMAS Iraq.

low level. Conversely, in complex environments, multiple variants of sophisticated, time-, victim-, and command-operated IEDs differ not only by type of initiation but by their design, components, layout, fabrication, charge size, and delivery method, making clearance a bespoke task, thereby raising the exposure threat to a high level.

For example, variants of command-operated IEDs (COIED) can include both wire and remote-controlled systems, the latter typically integrating modified, low-cost mobile telephones as arming mechanisms, including some with passive infrared (PIR) technology. In one instance, a variant included as many as twenty-two 9-volt batteries to extend the IED's "life."[16] Other victim-operated designs use nearly invisible fishing twine as a trip wire connected to a syringe or toggle switch functioning as triggering devices to close circuits after force is applied. These switches often indiscriminately target, but some anecdotal evidence suggests a clear intent on the part of ISIS to target explosive ordnance disposal (EOD) and IED disposal (IEDD) personnel conducting clearance operations through their placement in the proximity of other, often more obvious, EH. In addition, the threat level in complex environments is elevated due to exposure to deceased victims wearing suicide belts still buried by the hundreds in urban debris, posing biologic as well as explosive threats.[17]

Concentrations of conventional UXO in both environments obviously map to the intensity and progression of the fighting and tactics used by both sides. Conventional UXO threats include ISIS-manufactured mortars, rockets, projectiles, and grenades comparable in quality to ordnance used by coalition forces. Enhanced UXO threats include air-dropped munitions filled with ammonium nitrate-based explosives, modified 23 mm high-explosive incendiary projectiles for use as hand thrown and drone dropped weapons, and rockets improvised and fitted with chemical warheads sometimes containing low-grade mustard gas.[18]

EXPERIENCE. In response to conditions in Iraq, UNMAS reconstituted its clearance teams into light and heavy versions. Light, nationally staffed teams are small, highly mobile, lightly-equipped, self-supported, and specialize in spot tasks, and high-risk search and disposal conducted to international and UN IEDD standards, capable of deploying anywhere in the country within 24 hours notice and remaining on site, self-contained for 48 hours, supported by a geographic information system (GIS) and telephone link to off-site international staff. Heavy teams are area-focused, traditionally larger, usually equipped with mechanical assets but have reduced dependence on international staff. This "new business model" focuses on skill set development, increased reliance on national staff, and leveraging international staff as knowledge "multipliers" to maintain standards and reduce costs.[19]

ELEMENTS. Given that known or suspected contaminated areas are, by definition, inaccessible until cleared, they remain, de facto, part of an effective ISIS "de-stabilization" strategy,[20] posing a constant threat to disrupt clearance operations, contaminate new areas, and to re-contaminate areas already cleared. Recovery delays work to ISIS advantage by perpetuating economic hardship, political unrest, social strife, and individual anxiety. In one recent, typical month, one

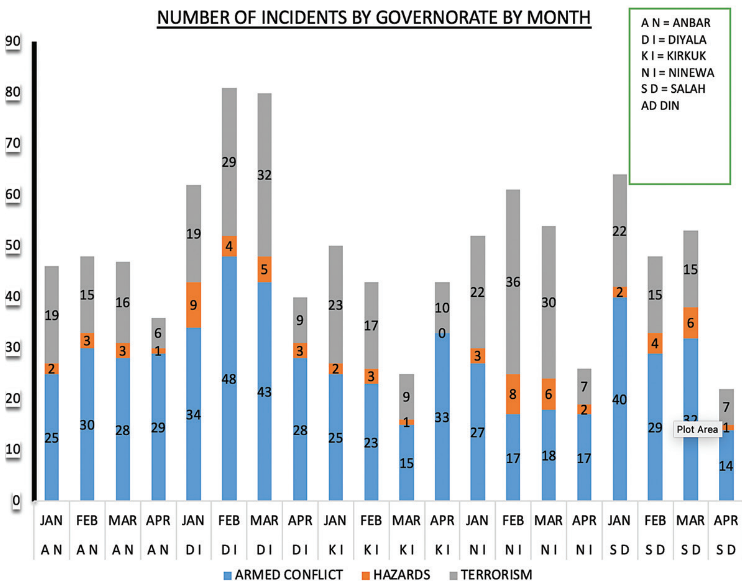


Figure 1. Number of incidents by governorate according to month.
Figure courtesy of Carol Cleary, based on UNDSS data, 1 January - 15 April 2020, inclusive.

Environmental Factor	Urban: Town or City 3D – complex	Lethality Index Score	20	*20*
Technical Factor	Switch Type		10	*10*
	Design		10	*10*
	Distribution		3	*3*
	Clutter		2	*2*
	Access		3	*3*
	Exposure/Degradation		3	*3*
	Ease to Locate		5	*5*
		Lethality Index Score	36	*36*
Cumulative Lethality Index Score		20 * 36 = 720		*20 * 36 = 720*

Table 1.
All tables courtesy of the author.

of three UNMAS clearance teams deployed had to abort 66 percent of missions as a direct consequence of "day of" security reassessments or authorities' denial of access to sites attributable to potential ISIS threats in its areas of operations, thereby adding to overall costs.[21]

As of early 2020, intelligence agencies see incident trends increasing (see Figure 1) in the governorates comprising the "disputed areas." For example, Ninewa and Salah al-Din show slight decreases for the first fifteen days of April 2020 when compared with the first quarter monthly averages, while other governorates show an increase. As of January 2020, various intelligence services estimate ISIS strength increasing over the past 12 months ranging from a low of 5,000[22,23] to 10,000 split between field and sleeper cell elements,[24] to a high of 18,000,[25] highly concentrated in the so-called liberated or disputed areas (see Figure 2 and Figure 3).[26] ISIS's own data from Nada, the ISIS digital weekly report, typically trend lower than open-source compilations released by intelligence and government agencies;[27] clearly, contaminated areas work to their advantage as they wage a "war of attrition."

MEASUREMENT. Traditional measurement of humanitarian mine action (HMA) focuses nearly exclusively on extent as a factor (i.e., square meters of land physically cleared), with additional metrics such as the amount, location, and concentration of EH removed/rendered safe in the process routinely used to supplement report.[28] However, this like-for-like comparison between contaminated areas fails to account for those other factors that contribute to time-on-task: environment type, exposure of operators to threats by device type and/or its design, skills, and assets appropriate for clearance and safe removal of threats as assessed, and security as a function of ISIS element activity. How then to evaluate cost-effective, efficient, safe, and timely clearance for Iraq's varying threat conditions and complexities?

INDEX. Logically, the more hazardous the EH task, the more time required for safe clearance, removal, and disposal of hazards. Hence, the need to calculate the relative "hazardousness" or the potential for a task to cause death, serious harm, or damage. Calculating this lethality starts with the systematic measurement of evidence-based threat data, in this case compiled for Iraq's environmental conditions and technical complexity. Variables impinge upon cost-effective, safe, and timely EH clearance conducted to IMAS standards. If reliable, such data, when analyzed and indexed, can aid decision making relating to clearance team composition, structure, training, and deployment (i.e., assigning teams appropriately trained for each task) with a net gain of increased team efficiency, team member protection, and better value for money for the donor.

DATA. To develop its lethality index,[29] UNMAS began with clearance data from two IED areas: (1) more than 500 IED clearance tasks in Fallujah and environs, indicative of a simple environment[30] and (2) more than 1,000 IED clearance tasks in Mosul, indicative of a complex environment, and then added both the concept of (3) two-dimensional and three-dimensional search; and then, finally, (4) definitions of urban and rural landscapes from census methodologies.[31] Through this combination and permutation of the various derived environmental and technical factors (see Table 2), UNMAS could assign scores consistently for IED locations as indicated along with their lethality index scoring.

UNMAS next evaluated IEDs recovered in Iraq for impact of their technical complexities on actual render safe procedures. Scores are either evidence-based or assessed depending upon whether the lethality index is being used as a predictive or descriptive tool.

PHASES. As stated, time-on-task is a function of clearance conditions and these are directly related to lethality. Based on historical data for Iraq, the "more lethal" tasks tend to take priority because, in a post-event environment, clearance of urban sites (which are followed by rural sites) directly leads to stabilization, reconstruction, and development.[32] While this gives a useful indication of the progression of likely task types as time progresses in such post-event environments, it does not describe the actual clearance achieved through those transitioning time periods.

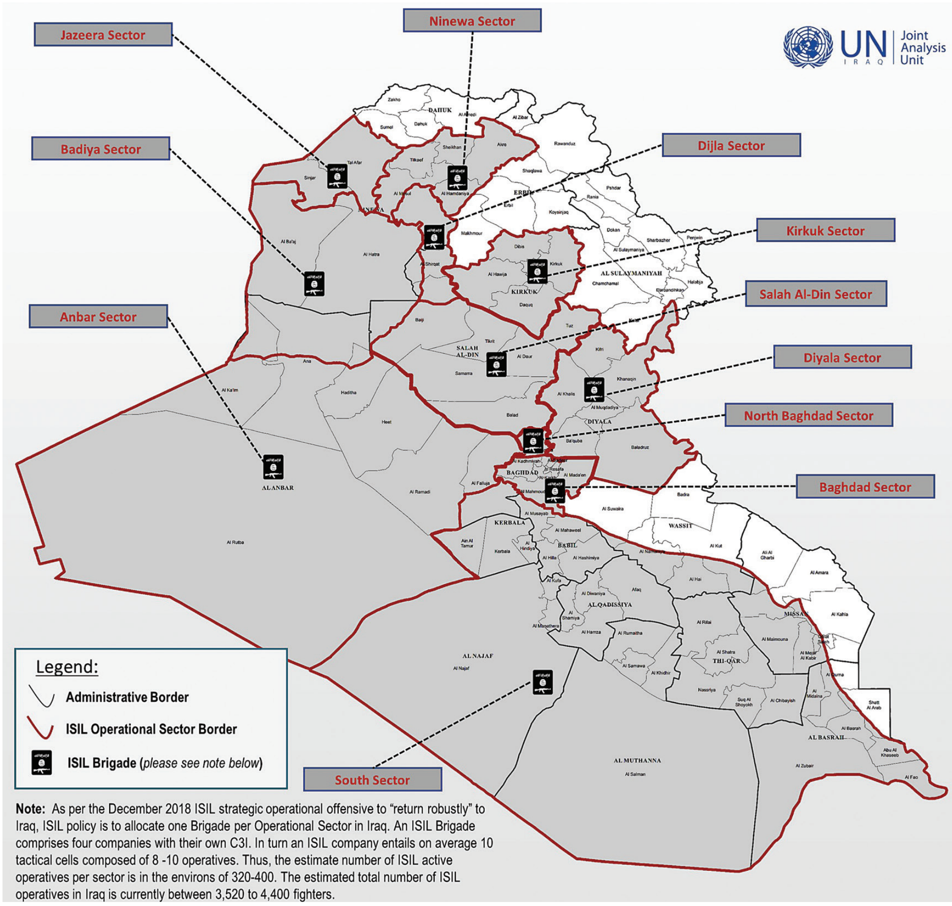


Figure 2. ISIL Operational Sectors in Iraq.
Figure courtesy of United Nations Joint Analysis Unit, Iraq.

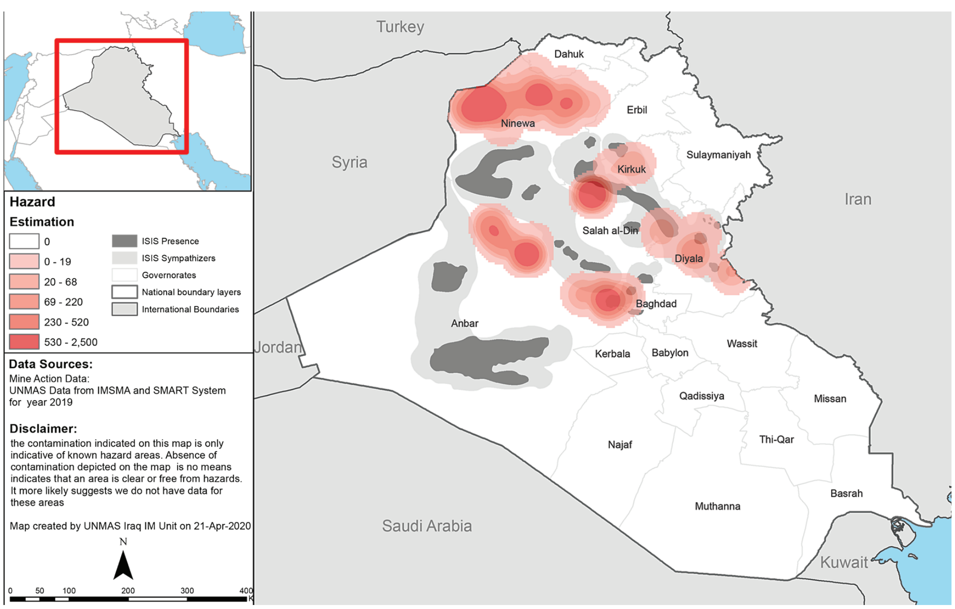


Figure 3. UNMAS Data from IMSMA and SMART System for 2019.
Figure courtesy of UNMAS Iraq Information Management Unit.

UNMAS analyzed field data for square meters searched as a function of time to locate and render safe/remove EH for three phases of clearance task types: (1) heavily contaminated sites, largely in populated areas and often in support of stabilization activities in urban areas prioritized; (2) more open and rural areas often based on incomplete or inaccurate hazard data; and (3) open and rural areas based on a more up-to-date and accurate hazard database with the following observations related to impact of time on clearance: [33]

In phase 1, thorough iNTS reports had already confirmed the presence of EH prior to teams' deployment to task locations. Due to the condition of many of these sites, including the presence of collapsed buildings and rubble, a requirement to use high-risk search teams meant that areas cleared were relatively small, though the quantities of EH recovered were relatively high.

In phases 2 and 3, a shift to more rural areas saw a rapidly increasing area of land cleared with an accompanying decrease in items of EH recovered. This again raises the issue of whether area cleared is an indicator of efficiency when the data to the contrary indicates clearance environment and complexity as likely drivers.[34]

Over time, as the main focus of clearance activities transitions from complex urban environments to rural simple environments and the concentration of contamination decreases, larger areas searched yield fewer IEDs rendered safe, suggesting a different set of parameters influences the devices present. This may specifically relate to tactical requirements at different stages of hostilities, including whether used for offense or defense. Particularly notable when used as a predictor for the lethality index, data compiled shows little-to-no evidence of device degradation over time.

UTILITY. Accepting the evidence presented thus far, the lethality index arguably has utility both as a

- **Descriptor.** Given detailed information for a specific clearance location (for example through iNTS reports or previous clearance activities), the index can generate an evidence-based metric as a basis to manage safety and efficiency by ensuring the most appropriate assets for the task.

41

An improvised directional main charge inal-Shifa Hospital, West Mosul. Similar items were found daisy chained together with detonating cord and connected to victim-operated switches. These types of devices with variable and complex emplacements are typical of 'Complex 3 Dimensional Urban' environments.
Image courtesy of UNMAS.

Environmental Factors	Description
Designation	EH landscapes in Iraq may be characterized as: **Rural** – Normally open, flat areas which may or may not be cultivated. Normally free of large quantities of waste or foreign objects. Low population density. **Urban** – Normally developed areas, featuring high concentrations of buildings, infrastructure and support services. Generally cluttered and may contain large quantities of waste and/or foreign objects. High population density.
Classification	EH environments in Iraq may be classified by dimension and technical sophistication: **2-Dimensional** (2-D) – EH environments requiring clearance across surface and depth (sub-surface) planes. **3-Dimensional** (3-D) – EH environments requiring clearance across surface, depth (sub-surface), and vertical (walls) planes. **Simple** – Consistent IED placement, location, pattern, relatively easy to detect; IEDs relatively simple in design in relation to render safe procedures required. Consequences of accidental initiation during render safe procedures are manageable. **Complex** – Inconsistent IED placement, location, pattern, relatively difficult to detect; IEDs relatively complex in design in relation to render safe procedures. Consequences of accidental initiation during render safe procedures are significant.
Lethality Index Score	A number assigned to denote lethality relative to referent environmental factors, their influence on render safe procedures and associated risk. Scores range from 0 (no lethality) to 10 (extreme lethality).

Table 2.

- **Predictor.** In the preparation of future clearance contracts, or prior to moving clearance capabilities to new areas, the lethality index can give a metric to guide the selection of the most appropriately trained, structured, and equipped clearance team based on the expected lethality of the task location.

PRACTICALITY. Whether used as a descriptor or predictor, the lethality index is computed the same way: the environmental score is multiplied by the overall total for the technical factors resulting in a highest possible score of 720 to reflect the most complex combinations of environmental and technical factors, with a lowest score of thirty-five reflecting the simplest possible combination of environmental and technical factors. The three following examples drawn from completed UNMAS IED clearance tasks represent different environments and geographical locations, types, and quantities of IEDs. A lethality index score is given based upon a likely predictive score

Environmental Factor	Classification	Lethality Index Score
Rural: Open uncultivated land	2-D, simple	1, 2 = 2
Rural: Open cultivated land	2-D, simple	1, 2 = 2
Rural: Open with isolated dwellings	2-D, complex	1, 4 = 4
Urban: Open space	2-D, complex	1, 8 = 8
Urban: Village	3-D, complex	2, 8 = 16
Urban: Fringe of town or city	3-D, complex	2, 8 = 16
Urban: Town or City	3-D, complex	2, 10 = 20

Table 3. * The index does not currently consider residential clearance activities.

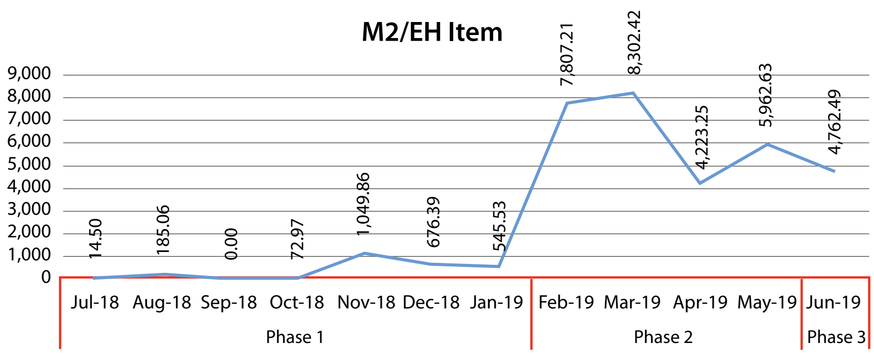


Figure 4. Square meters searched versus items of EH recovered between Jul 18 and Jun 19.
Figure courtesy of Nathan Williams, Operations Planning Officer, UNMAS Iraq.

Technical Factor	Description	Lethality Index Score
Switch Type	• Time (not recovered as complete IED) • Victim Operated (most commonly High Metal Content Pressure Plate) • Command (including wire, RC armed PIR) [for multiple IED, use highest score]	n/a 5 Wire = 5 RC = 6 PIR = 10
Design	Ranges from • Simple (single switch, single power source, simple main charge) *to* • Intermediate (simple plus anti-handling) *to* • Complex (multiple switches, multiple main charges, remoted power sources, complex anti-handling)	Simple = 1 Intermediate = 5 Complex = 10
Distribution	IEDs distribution/distributed • Facilitates easy identification of components • As part of a defensive belt • Randomly across an area with no obvious pattern	 1 2 3
Clutter	• Area free of metallic, other contamination • Area littered, including with metallic objects	1 2
Access	• Location freely and easily accessible to search teams and IED Operator. Clearance site simple to mark and access control (civilian) is possible • Location congested, severely constrains search planning and direction, access control is not possible.	1 3
Degradation	• Clear evidence of aging/weathering of the task location. Devices likely in place in excess of 12 months • No evidence of aging/weathering of the task location. Devices in place less than 12 months or may have been protected	1 3
Ease to locate Visual	• IED location obvious, often visible by eye, easily confirmed with detector • IED location not apparent, not visible by eye, difficult to locate with detectors	1 5

Table 4. * The index does not currently consider residential clearance activities.

(see Tables 4–6, predictive scores shown in italics, shaded column, far right) prior to the task commencing and a descriptive score based on the physical evidence gathered during that task.

Example One: al-Shifa Hospital, West Mosul

Al-Shifa hospital was an ISIS headquarters, weapons store, and weapon manufacturing facility in West Mosul. Close to the al-Maedan district, the hospital also was the scene of some of the most violent fighting during the battle to reclaim Mosul. UXO and IED contamination was extensive, and device complexity varied from simple to complex throughout the site.

Example Two: al-Shuhada District, Fallujah

ISIS made significant use of IED obstacle belts around the city of Fallujah to defend against the most likely directional advance of Iraqi Security Forces (ISF) in any attempt to retake the city. IEDs were laid in uniform patterns in many areas—including al-Shuhada—almost always using a standard device design. Occasional anti-handling devices were located during clearance (approximately 10 percent of total devices).

Example Three: Rawa'h, West Anbar

A single suspected IED near a track previously used by ISF on security patrols was successfully rendered safe after an UNMAS search team located a suspicious wire. The IED operator rendered safe a remote-controlled armed PIR switch connected to two directional main charges. While the device type was complex, the environment and other technical factors proved "less lethal" as reflected in the cumulative Lethality Index Score.

Although useful as "stand-alone" metrics, as cumulative scores paired with IMAS IEDD skill levels (see Table 7), they become a useful tool to assist in assigning appropriately trained IEDD operators based upon environmental and technical complexity.

MULTIPLIER. Given the trend in Iraq toward employment of local national clearance capabilities as a cost-saving strategy, the index serves as a multiplier by allowing for assignment of locally staffed teams appropriate for tasks to work independently with the option of technical oversight and referral via a telephone thereby (1) leveraging limited

43

Environmental Factor	Urban: Town or City 3D – complex	Lethality Index Score	20	*20*
Technical Factor	Switch Type		5	*5*
	Design		5	*1*
	Distribution		2	*2*
	Clutter		1	*1*
	Access		1	*1*
	Exposure/Degradation		1	*1*
	Ease to Locate		1	*1*
		Lethality Index Score	16	*12*
Cumulative Lethality Index Score		8 * 16 = 128		*8 * 12 = 96*

Table 5.

Environmental Factor	Urban: Town or City 3D – complex	Lethality Index Score	20	*20*
Technical Factor	Switch Type		10	*5*
	Design		10	*5*
	Distribution		1	*1*
	Clutter		1	*1*
	Access		1	*1*
	Exposure/Degradation		3	*3*
	Ease to Locate		5	*5*
		Lethality Index Score	31	*21*
Cumulative Lethality Index Score		2 * 31 = 62		*2 * 21 = 42*

Table 6.

Lethality Index Score							
0	100	200	300	400	500	600	700
IMAS IEDD Level 3				IMAS IEDD Level 3+ (Advanced)			
Qualification & Experience							

Table 7.

international technical advisers on a task basis; and, longer term, (2) reducing reliance on international advisors as local team expertise develops also on a task basis; and, (3) contributing to an earlier "phasing out" of expensive international heavy clearance teams.

BENEFITS. So what does the lethality index offer EH clearance actors?

First, a clear basis for identifying appropriately trained and equipped teams for clearance tasks.

Second, a tool to identify cost savings early in the procurement cycle particularly related to clearance teams tailored for requirements as opposed to technical proposals often written by commercial companies often based on large EH teams dominated by international personnel and a less-than-transparent process sometimes viewed privately as "less-than-educated guesswork."

Third, support for the nationalization and development of local clearance teams by rationalizing the process of training design, training delivery, on-the-job training, and continuing professional development, linking the transition of search and IEDD activities from taught mechanistic drills to more intuitive skills.

CONCLUSION. Although the United Nations Sustainable Development Goals (SDGs) recognize the need for EH clearance as an enabler of broader socioeconomic development, funding depends upon strong arguments supported by data to respond to legitimate donor concerns related to both value for money and return on investment.

In response to the value for money concern, UNMAS has evaluated the IED threat in Iraq focusing on a composite measurement of those environmental and technical factors affecting cost-effective, safe, timely, optimized clearance done to IMAS standards while considering each as a variable contributing to overall task lethality as a lead factor determining time-on-task and overall efficiency. Although not a sine qua non, the lethality index, when coupled with other factors such as IMAS IEDD skill levels and related costs, could offer the mine action community a useful conceptual basis to continue to refine and develop meaningful and metric based tools that are able to respond to the fundamental donor question, "How much should clearance cost?" for a given environment in a manner more reflective of the true range of factors affecting clearance.

In response to return on investment, the mine action community in Iraq still has a need for an economically derived baseline to measure "opportunity cost," or economic and social gains either conveyed or deferred as a function of clearance completed versus not completed. Arguably, this is the true value of clearance and a separate subject for another time.

See endnotes page 70

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Mark Wilkinson, Ph.D., a UNMAS (Iraq) Explosive Hazard Management Team Lead, has twenty years of professional experience in military and HMA. As a former British Army Ammunition Technical Officer, he worked as a High Threat IEDD Operator in several operational environments before transitioning to HMA. His HMA experience has developed through time spent as an IEDD operator, then a Program Manager, before moving to UNMAS. His academic background includes a master's degree in global security and a Ph.D. in politics and international studies. His thesis on Arms Control and Intelligence has been published internationally as the book *Before Intelligence Failed.* He is also a Visiting Fellow at the University of Nottingham Centre for Conflict, Security and Terrorism where he maintains an active research agenda.

SEVENTH MINE ACTION TECHNOLOGY WORKSHOP
A SPACE FOR INNOVATION

By Arsen Khanyan and Inna Cruz [GICHD]

Attendees listen to presentations at the Seventh Mine Action Technology Workshop in Basel, Switzerland.
All graphics courtesy of the authors.

The 7th edition of the Mine Action Technology Workshop, a biennial event organized by the Geneva International Centre for Humanitarian Demining (GICHD), took place from 7 to 8 November 2019 in Basel, Switzerland. Titled *Remote Sensing and Robotics in Mine Action*, the workshop welcomed 165 participants from forty-nine countries, representing eighty-five organizations.[1] It offered a platform to discuss and share ideas and experiences that promote the efficient use of innovation and technology in humanitarian mine action (HMA).

This unique event is aimed at bringing together mine action professionals, manufacturers, national authorities, operators, and representatives from the United Nations as well as other international organizations. It focuses on the vital role technological innovation plays in increasing efficiency and effectiveness in emergency response, humanitarian aid, and development.

TECHNOLOGICAL INNOVATION RESHAPES HMA

Innovation is reshaping HMA, bringing about fundamentally new and potentially much more efficient approaches to our work. The changes represent a real opportunity for the mine action sector to learn about new, more effective, and safer ways of working. For example, remote sensing is now used in mine action, not only to assist in planning, monitoring, and evaluating clearance operations, but also to support the land release process and help measure impact.

Initially developed for military purposes, unmanned aerial systems (UAS) have rapidly gained traction in civilian sectors, and increasingly so in humanitarian aid and development assistance. In HMA, UAS are currently used as one of many tools to support operations to tackle the most important challenge—human safety. Numerous presentations given during the workshop were testament to the fact that information gathered from the use of UAS in HMA adds value across a wide range of different applications in planning, implementing, and impact-assessing activities.

LESSONS FROM THE FIELD

During the workshop, mine action operators, technology developers, and researchers showed examples of how UAS can support mine action operations in the field. They presented innovative applications for close inspection, direct and indirect evidence detection, ground penetrating radar (GPR) potential, and the use of multispectral and hyperspectral sensors for evidence records. The workshop also illustrated how HMA organizations are currently using or testing UAS in their operations.

The HALO Trust presented several case studies where UAS were being used in mine-affected countries and territories (Angola, Cambodia, Colombia, Georgia, Guinea-Bissau, Lao PDR, Somaliland, Sri Lanka, and the West Bank) to support various mine action activities, such as pre-deployment planning, remote monitoring of operations, terrain inspection, and impact assessment. The evidence for using UAS in operational planning was also presented by (MAG) Mines Advisory Group, who have used UAS in northeast and northwest Cambodia. High-resolution images were used by MAG for terrain and vegetation analysis to plan task sites prior to clearance and to provide a better overview for deploying various mine clearance assets (mechanical, animal, and manual detection systems).

John Fardoulis of Mobility Robotics and Humanity and Inclusion presents on drone trials in Chad.

45

CATEGORY	EXAMPLES
Non-Technical Survey	Confirm visible (direct or indirect) evidence of mines, explosive ordnance or other evidence to identify a suspected hazardous area (SHA)
	Confirm evidence of land use to contribute to all reasonable effort for area cancellation
	Conduct an assessment of soil, topography, and other environmental characteristics of SHAs and confirmed hazardous areas (CHAs)
	Quality control of data and information
Operational Oversight	Task planning
	Mapping of demolition sites/effects and mine lines
	Cordon enforcement
	Demolition monitoring
	Mapping progress and completion
	Accident investigation
Post-Clearance	Monitoring and evaluation of clearance impact
	External communications
Other	Damage assessment after unplanned explosions at munitions sites
	Analysis of current and planned ammunition storage areas
	High-resolution mapping
	Further spatial analyses
	Task prioritization

Figure 1. The demonstrated use of UAS.

CATEGORY	CHALLENGE/OBSTACLE/RISK
Political	Perception of drones and their usage by criminals (e.g., ISIS in Iraq)
Economic	High cost of some of the larger drones
	Cost of failure
	Cost of logistics and support
Social	Technophobia
	Local capacity
	Staff turnover within mine action programs (skills/knowledge loss in programs)
Technological	Lack of spare parts in country
	Lack of repair facilities
	Short flight duration
Legal/ Regulatory	Understanding aviation regulations in each country, which include: • Import/export permissions; • Permission for use from local government and local communities; • Flight consent from the airspace controlling authority; • Awareness of limitations with regards to forbidden areas, maximum altitude levels; • Licenses and additional permissions required, depending on each country's regulations.
	Privacy and data protection laws
	Lack of technological and operational standards to guide safe and consistent performance of UAVs in HMA
Environmental	Soil conditions (which dictate choice of sensors)
	Depth of mines and explosive ordnance

Figure 2. Risks and challenges of using UAS in HMA.

Norwegian People's Aid (NPA) has been testing UAS in Bosnia and Herzegovina and in Montenegro since 2018, using red-green-blue (RGB) color and thermal cameras to assist in drawing more precise boundaries of suspected hazardous areas (SHAs) and assess the environmental characteristics of SHAs. UAS are also able to more accurately locate evidence that was previously found using other techniques.

The presentation made by the GICHD covered several aspects of UAS use in mine action and described the UAS module available on the GICHD e-learning platform. The platform contains case studies that explore how UAS imagery enhances land release activities as well as how UAS provide practical advice and guidance on UAS operations.

Mobility Robotics and Humanity and Inclusion (HI) presented on the Odyssey 2025 project and discussed their trials in Chad. This project further demonstrated how UAS and remote sensing could be used in pre-deployment planning, cartography, and operational research. In particular, it has been demonstrated that an infrared camera was able to geolocate anti-vehicle mines buried in sandy soil, thus facilitating manual demining activities.

UAS pose multiple challenges for HMA operators, who cite legal and regulatory issues as the most common, particularly individual countries' UAS regulations and importation/customs restrictions. The main challenges are listed in Figure 2.

RESEARCH AND DEVELOPMENT

Several organizations and research institutions presented their work on integrated remote sensing technologies:

The project SAFEDRONE, presented by the Counter Improvised Explosive Devices Centre of Excellence (C-IED COE), aims to develop and test an enhanced system for improvised explosive device (IED) detection using a high-resolution GPR mounted on board an unmanned aerial vehicle (UAV) that is being developed in cooperation with the University of Oviedo (Spain). The methodology is based on a synthetic aperture radar technique, high positioning accuracy (< 2 cm), and a deep and broad processing of signals by means of groups of coherent algorithms and artificial intelligence. Field tests of the system are planned to begin in October 2020.

In their presentation on the development and tests of the SeaTerra unexploded ordnance (UXO) survey drone system, UXO survey and clearance company SeaTerra summarized the different criteria to keep in mind when deciding to purchase and use drones; these included price, weight/payload, data, stability, sensors, positioning, and battery life.

Cobham Aerospace Connectivity presented their product, Amulet UAS, a medium-sized UAV that carries a GPR capable of searching for explosive ordnance (EO) in areas that would otherwise be too high-risk or inaccessible for human deminers.

The Urs Endress Foundation presented on the FindMine project, which has been running since 2016, in collaboration with Swiss and German universities, to develop a UAV-based system for mine detection. The system consists of a multirotor UAV with a ground penetrating synthetic aperture radar[2] as its prime sensor for mine localization. The system will be further developed by integrating additional sensors and by increasing flying capabilities in suspect buildings, dense forests, and jungles.

A panel discussion on remote sensing and IMAS.

Exploration for Humanity, together with Mobile Geophysical Technologies (MGT), presented the MGT DroneMag5 Landmine Detection System "Penta Mag" using eight rotors, a coaxial configuration multirotor UAV used for ordnance detection with magnetic sensors. The Penta Mag system contains five fluxgate sensors[3] in horizontal alignment and is particularly developed for use on a multirotor.

RPS Energy Ltd. presented an overview of their remote aerial multidiscipline survey system that consists of a small unmanned aircraft fitted with various payloads to collect geodetic, remote sensing, and instrument data sets to aid in the identification of EO. To assist in the data processing phase, RPS has developed bespoke artificial intelligence software programs that can quickly analyze large data sets and present their findings as a level-of-certainty percentile.

Ukrainian Multirotor Technologies (UMT) presented the results of a field study to remotely detect and identify the most common rocket-launched ordnance, relying on rapid, wide-area scanning by a UAV-based, microfabricated, atomic magnetometer mounted on a UMT Cicada-M hybrid-powered UAS platform.

SENSYS presented the MagDrone R4, an ultralight-weight magnetometer survey kit with multiple sensors to allow either large area coverage per flight time or high-resolution area scans. Due to its reduced weight of less than 4 kg and unique folding mechanisms, SENSYS suggested that it could be used with inexpensive commercial drones/UAVs.

UNIQUE CHALLENGES: URBAN AREAS

The participants of the technology workshop also discussed the significance of technological innovation in urban areas. Due to changes in the characteristics and nature of conflicts and widespread use of IEDs in urban areas, traditional clearing operations have become increasingly difficult in cities. UAS have been used to check roofs and inside buildings. In this context, the consulting and engineering firm Tetra Tech presented on the use of UAS in urban environments and presented UAS trials to address passive infrared threats in Syrian and Iraqi cities. To help assess the threat inside the IED-suspected buildings, Tetra Tech employs relatively small drones that are commonly used in urban areas. Numerous mine action operators are investigating the use of UAS platforms and sensors during technical survey for IED clearance in urban areas.

SIGNIFICANCE OF COLLABORATION AND KNOWLEDGE EXCHANGE

Feedback from workshop participants during and after the event indicate that the Mine Action Technology Workshop will continue to be crucial for the sector. Workshop attendees emphasized that the full potential of remote-sensing technologies can only be achieved through close collaboration between national operators and research institutions by exactly defining field needs, adapting technology to field conditions, and testing in the field. One of the main benefits of such an event is to provide a platform for product developers and end users to meet and exchange experiences and opinions. This serves to provide insight into the practicality, limitations, and achievements of the various technologies that are being developed and used to enhance HMA. This is not only on an operational level but also from an information management, planning, and decision-making perspective.

If you have any comments or questions, please contact the GICHD technology team at technology@gichd.org.

See endnotes page 70

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Arsen Khanyan joined the Geneva International Centre for Humanitarian Demining (GICHD) in 2018. He is currently working as Programme Officer on policy-related topics, particularly on the links between mine action, peace, security, and Sustainable Development Goals. Prior to joining the GICHD, Khanyan worked for the UN High Commissioner for Refugees (UNHCR) and Office of the High Commissioner for Human Rights (OHCHR) in Geneva and for the Council of Europe Liaison Office to the EU in Brussels. Khanyan holds a master's degree in Russian and Eurasian studies (international affairs) from the University of Geneva and a second master's degree in international affairs and diplomacy from the European University of Armenia.

Inna Cruz
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Inna Cruz is an independent Information Management Advisor. She worked at the GICHD for ten years. Her expertise lies in geographic information systems (GIS), remote sensing, aerial imagery, cartography, and geodetics. One of her key projects was the use of UAS for mapping and reporting in mine action. She was also the country focal point for support to users in Eastern Europe and the Caucasus. Prior to joining the GICHD, she worked as a consultant for two projects for the United Nations Environmental Programme (UNEP) using GIS technologies. Cruz has a degree in environmental sciences from the National University of Kyiv-Mohyla Academy in Ukraine and a master's degree in environmental natural sciences from Geneva University, and she recently obtained Project Management Certification (PMP).

47

UNDERSTANDING THE LOGIC OF REBEL RESTRAINT ON LANDMINE USE[1]

By Henrique Garbino [Uppsala University]

Non-state armed groups (NSAGs)[2] have become the most frequent users of landmines and the main drivers of new landmine contamination. Often portrayed as the "perfect soldier" due to their low cost, easy availability, and high lethality, landmines have become the weapon of choice of many rebel groups. An initial assessment by Geneva Call reported that, in 2005, at least sixty rebel groups in twenty-four countries had used mines.[3-5] In contrast with state governments, rebels have considerably less incentives to comply with existing humanitarian norms.[6] Engaging them in restricting or renouncing the use of landmines remains one of the most pressing practical obstacles toward a mine-free world.

Anecdotal evidence suggests that the use of landmines and other explosive devices varies significantly in the level of restraint exercised by NSAGs. Some rebel groups indiscriminately lay mines irrespective of potential collateral damage,[4] some directly target civilians,[7] and others restrict themselves to command-detonated devices against government forces.[8] Still, some NSAGs have committed to the total ban on landmines and others engage in mine action activities in one way or another.[9] This wide difference in behavior raises the question: *What explains variation in rebel restraint on landmine use?*

Restraint on landmine use can be divided into two components. First, *landmine use* reflects the different categories in which landmines are employed, namely in *strategy, type of device, trigger mechanism, location, frequency,* and *information-sharing.* Second, *restraint* entails the deliberate behavior to restrict the use of violence. Civilians are victimized by unrestrained violence either by direct one-sided violence or by collateral damage from the conflict. Therefore, landmine use should vary depending on a given NSAG's restraint behavior.

Significant academic attention has been devoted to the causes and dynamics of violence against civilians. However, scholars have given much less emphasis on explaining the cases when violence does not happen, i.e., cases of restraint and compliance to humanitarian norms.[10] Throughout this article, restraint is defined as deliberate actions limiting the use of violence,[11] while compliance takes the meaning of adherence to humanitarian norms, more specifically to International Humanitarian Law (IHL).[6] Because IHL explicitly calls for restraint in the use of violence, it is often hard to distinguish the two concepts both in practice and in theory. Even though the literature on both concepts will be addressed in this section, it is worth noting that restraint can be exercised without compliance to humanitarian norms, such as when it is addressed only to specific groups.

This article aims to enhance the understanding of different incentives and dynamics at play on rebel behavior. Insights on this field could inform government authorities, civil-society organizations, and advocacy groups when engaging with NSAGs.

RESTRAINT ON LANDMINE USE

Previous scholarship has addressed the logic of violence and restraint for different patterns of violence against civilians, such as indiscriminate violence, genocide and ethnic cleansing, and gender-based and sexual violence.[12] Similarly, scholars have concentrated on explaining compliance to humanitarian norms, with a focus on child soldiering and the protection of prisoners of war, aid workers, and other categories of non-combatants. While some scholars have developed theoretical frameworks that could be generalized to other contexts, only a small number of authors have developed theoretical explanations of rebel restraint on landmine use.[13,14] However, meaningfully contributing to the scarce literature on this topic, these authors adopt a rather narrow measure of restraint as commitment and compliance to a total ban on landmines.

Inherently indiscriminate weapons, anti-personnel landmines aim not to kill but maim the enemy, so that the wounded and agonizing soldier would further consume the enemy's resources and decrease their morale. Coupled with its secretive and unpredictable nature, landmines are highly effective in creating a permanent condition of uncertainty and fear. Whether they are placed to directly target civilians or are left as remnants of war, landmines can cause significant harm to civilians and disrupt the social fabric of affected communities. In addition to the physical harm leading to death and permanent disabilities to survivors, psychological trauma, fear, and stress are widespread in mine-affected populations. Communities also suffer collectively by restricted access to livelihoods, key infrastructure, water sources, and are either forced to move or impeded to return to their homes.[15]

Given its nature, landmine use considerably differs from other forms of violence against civilians, such as indiscriminate or sexual violence. First, landmine use entails significant logistic and coordination capabilities. It follows that landmine use should reflect some strategic, rather than opportunistic, reasoning. Second, due to their static nature, landmines bring about geographically localized effects, meaning that landmines are more likely to affect specific groups depending on where they are placed. Third, most landmines remain active long after conflicts have ended, when virtually all mine victims

Variable	Indicators	Variation	Violence against civilians	Collateral damage	Level of restraint
Restraint on landmine use	***strategy***	nuisance	direct	accepted	low
		economic gain	direct	accepted	low
		defensive	indirect	accepted	moderate
		offensive	indirect	avoided	high
	type of device	booby-trap	direct	accepted	low
		anti-personnel mine	indirect	accepted	moderate
		anti-vehicle mine	indirect	avoided	high
	trigger mechanism	victim-activated	indirect	accepted	moderate
		command-detonated	indirect	avoided	high
	location	civilian targets	direct	accepted	low
		populated areas	indirect	accepted	moderate
		military targets	indirect	avoided	high
		unpopulated areas	indirect	avoided	high
	frequency	frequent	indirect	accepted	moderate
		sporadic	indirect	avoided	high
	markings	unmarked minefields	indirect	accepted	moderate
		marked minefields	indirect	avoided	high
	direct restraint	terror tactics	direct	accepted	low
		no restraint policy	indirect	accepted	moderate
		restraint policy	indirect	avoided	high

Table 1. Conceptualization of rebel restraint on landmine use.
All graphics courtesy of the author.

are non-combatants. Accounting for this longstanding and usually delayed effect on civilians requires long-term perspective and strategic thinking. Fourth, civilians may be either the direct target of mines or the collateral damage of the fighting; however, even in the latter case, armed groups should have accepted the risk of civilians falling victims of their mines.

Having said that, existing theories need to be adapted or reframed when examining landmine use; but it is first necessary to conceptualize what restraint on landmine use is and how it can vary.

Strategy. Factors such as the level of power asymmetry, the phase of the conflict, the extent of territorial control, the availability of landmines, and the knowledge in producing improvised explosive devices (IEDs) may all influence the strategy behind the use of landmines. A Geneva Call report identified four main strategies guiding mine use, namely *defensive, offensive, economic gain,* and *nuisance mining.*[4] In *defensive* strategies, landmines aim to deter an enemy attack and restrict access to particular areas or routes of military value. Among NSAGs, landmines are used for defensive purposes or for slowing down the movement of enemy troops. Mines may also be laid following a defensive rationale for the protection of the group's constituency, family members, or key individuals.[4] Landmines also serve an *offensive* strategy when their goal is to kill or maim the opposing force, such as to block escape routes during ambushes and counter-attacks, or in direct targeting of government forces or individuals.[4] When employed under an *economic gain* strategy, mines do not serve any direct military purpose but economic interests. Landmines are often laid to protect an important source of revenue such as coca crops in Latin America or diamond and gold mines in sub-Saharan Africa. However, in some cases, NSAGs may use landmines to directly extract revenues from the population, such as charging road tolls.[4] Other types of mine use that serve no direct military or economic purpose are sometimes labelled *nuisance mining.* This strategy has been used to disrupt access to key infrastructure. Landmine use that is aimed deliberately at civilians in order to empty territories, deny use of basic facilities, displace communities, isolate regions, or simply spread terror also falls under this category.[4]

Type of device. Landmines may serve different purposes depending on their main target. The most common types of landmine are *anti-personnel* and *anti-vehicle*, which are respectively designed to detonate by the presence, proximity, or contact of a person or vehicle. Although not considered landmines, the so-called *booby traps* are explosive devices disguised as otherwise harmless objects. Although other types of mines exist, this study is restricted to anti-personnel and anti-vehicle mines, and booby traps, which are the focus of the main treaties and are arguably more disruptive to civilian life than other types of explosive devices. In this regard, it is implied that rebel groups demonstrate different levels of restraint, depending on which type of device is mostly used. The use of anti-vehicle landmines implies a higher level of restraint, while the use of anti-personnel landmines and booby traps implies lower levels of restraint.

Trigger mechanisms. Mines and other explosive devices can be activated by a wide variety of trigger mechanisms, such as pressure, pull, tension release, or pressure release.[16] In relation to civilian harm, however, what matters most is whether the explosive device is *victim-activated* or *command-detonated*. Regardless of the exact type of trigger mechanism, civilians face significantly more risk if the device is *victim-activated*, that is, if the device is designed to detonate by the victim only, without any external action. *Command-detonated* explosive devices, conversely, are monitored and set off by an operator at a chosen moment, thus avoiding unnecessary collateral damage.[16] This does not mean that command-detonated devices present no risk whatsoever to civilians, as they can be used to directly target civilians, and, in case of failing to detonate, they are left as explosive hazards threatening the population.[17] Regarding the use of landmines and other explosives devices, restraint is thus higher for command-detonated devices and lower for victim-activated devices.

Location. The location of landmines depends mostly on their strategic use. However, in comparison with government forces, NSAGs often have less capacity to lay large quantities of mines, and, instead of large and coherent minefields, NSAGs tend to place mines in smaller, more precise locations.[18] Rebel groups are also more likely to deploy landmines more indiscriminately and near civilian-dense areas.[19] It follows that whether landmines are laid in areas with higher or lower risk to civilians can thus indicate different levels of restraint by rebel groups.

Frequency. The frequency in the use of landmines varies significantly among NSAGs. While some employ mines as their weapon of choice, others use them only sporadically, given a specific "need" or context in the conflict.[4] Again, frequency may also be subject not to a specific strategy or policy, but to contextual factors, such as group capacity, access to landmines, conflict dynamics, among others. Nonetheless, restraint on landmine use can also be demonstrated by the frequency that rebel groups lay mines or other explosive devices. It follows that, without considering other contextual factors, the lower the frequency of use, the higher the level of restraint.

Information-sharing. When compared to professional militaries, NSAGs are less likely to follow international marking standards[20] for their minefields.[9] For civilians, this means increased risk of inadvertently walking through minefields and increased costs in future mine clearance. Likewise, rebel minefields usually do not follow conventional patterns.[18,19] In 2006, at least thirty NSAGs had engaged in some kind of information-sharing or mine risk education to affected communities.[9] Therefore, restraint on landmine use is reflected by whether minefields and mined areas are marked, and on how information about them is recorded and shared.

Direct restraint. In addition to restraint in relation to the *use* of landmines, direct forms of restraint can also be found on the *non-use* of landmines. Direct restraint can be exercised by rebel groups in codes of conduct, internal policies, trainings, and doctrines, as well as in unilateral declarations and ceasefire or peace agreements. For example, the Colombian National Liberation Army's code of conduct explicitly mentions the duty to inform civilians of the location of mined areas.[21,22] Conversely, some rebel groups might not formally restrict their use of landmines but do so in practice. Other groups, however, might use landmines and other explosive devices in a virtually unrestrained way.

Taking into account how landmine use relates to violence against civilians, and, thus, restraint, Table 1 summarizes the conceptualization of rebel restraint on landmine use.

EXPLAINING VARIATION IN RESTRAINT ON LANDMINE USE

Current theories on restraint range from rationalist to sociological approaches. In one instance, restraint may be the product of a rational examination of different economic, political, and military interests. Armed groups consider factors such as reputation with their constituency and other stakeholders (e.g., international community), as well as the military advantage of having certain weapons or employing tactics.[23] Alternatively, restraint may be influenced by organizational factors, such as military culture, and both formal and informal socialization mechanisms.[24] Recent research found that NSAGs' behavior towards violence or restraint is the product of their sources of authority, beliefs, traditions, and the group members themselves.[11] Finally, contextual factors could lead to a lesser exercise of violence but not necessarily mean genuine restraint. Because this study is ultimately intended to understand the reasons of restraint, it is important to point to *what restraint is not*.

CONTEXTUAL FACTORS

Not all NSAGs are able to employ landmines, and reduction in landmine use does not mean genuine restraint was employed. A common example is the seasonal use of landmines, which are only seldom laid during winter due to frozen soil and heavy snowfall.[25] The systematic use of landmines requires significant logistic capability and group cohesion; therefore, an NSAG with decreased group capacity could display reduced use of landmines.[11] Likewise, decreased access to landmines and other explosive components, as well as technical expertise in production of handmade mines or IEDs, will limit landmine use. Finally, landmine use may be reduced due to evolving conflict dynamics, as NSAGs experiencing major victories are more likely to reduce landmine use.[4] Unrestrained behavior may also be subject to other dynamics, even if the rebel leadership is committed to limit the use of violence. Reasons for unrestrained behavior and noncompliance include conflicting military training and doctrine,[26] absence of political training,[27–30] and problems in leadership and command and control.[31]

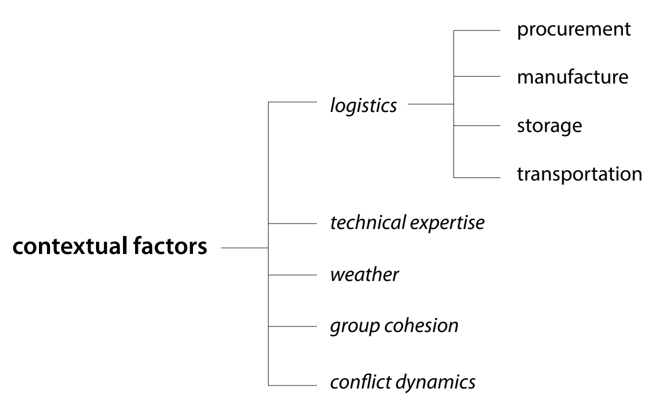

Figure 1. Contextual factors influencing reduction in landmine use.

STRATEGIC INCENTIVES

Although seemingly counterintuitive, landmine use may inflict significant *military and economic costs* on rebels. First, rebels are constantly victimized by their own mines, either during the production of improvised devices, when laying landmines, or unwillingly activating them after they have been laid. NSAGs largely underreport their own casualties due to the rebels' interests in portraying the image of a professional and cohesive group. However, the National Democratic Front in Myanmar stated that up to 80 percent of its handmade mine manufacturers died when assembling improvised landmines.[32] Likewise, the Sudan People's Liberation Movement's Army (SPLM/A) is believed to have suffered significant casualties from their own mines.[33] In these cases, exercising restraint on landmine use is a matter of safety and morale for the rebel group's own ranks, continuity of operations, and the group's very survival.

Second, particularly in the cases where NSAGs hold control of territory, using landmines in the land rebels are fighting for entails an inherent contradiction, as mine contamination and future mine clearance might be excessively costly.[34] Furthermore, NSAGs may be economically dependent on the revenues of the land, in which case denying access to it with landmines would decrease their revenues. Thus, it is expected that rebels would avoid contaminating productive land in their own territory.

A second category of strategic incentives of restraint are *political and reputational costs*. Landmine use can influence how NSAGs are perceived by their constituency and other domestic and international audiences. Civilian support has long been considered a central determinant of civil war outcomes,[35] as civilians provide recruits, food, information, and safe hiding places. It follows that dependence on civilian support creates restraint on the level of one-sided violence,[36] as well as incentives to protect the armed group's constituency.[37] Under a similar logic, de la Calle[38] argues that civilian victimization is driven by rebel strength, in the sense that weaker rebels would seek civilian support.

Furthermore, local communities are particularly vulnerable to landmines and other explosive devices. An NSAG in Myanmar, for instance, has allegedly changed their mine use policy after realizing that up to 30 percent of mine victims came from the rebels' own ethnic group.[32] As a direct consequence of victimization by landmines, local communities could decrease support to the armed group.[34] It is possible that the affected communities would demand the NSAGs to restrict their use of landmines and demine certain areas, as observed in Colombia[39] and Senegal.[40]

Civilian victimization also entails significant reputational costs to other domestic and international audiences, particularly towards human rights-conscious audiences.[6] Abiding to a shared legal framework—such as international law—plays in favor of rebel groups' perceived political legitimacy. Exercising restraint on landmine use, therefore, entails compliance to international (and sometimes domestic) law[6,19,41] and could increase the likelihood of external support, political participation, and leverage in negotiations. As an example, Herr found that SPLM/A adhered to the landmine ban due to transnational pressure and fear of legitimacy loss.[42]

Likewise, compliance with IHL may ensure practical and legal securities to rebels, in particular to the leadership, such as granting the legal status of combatants and reciprocity in treatment by government forces.[6] Accordingly, a recent study led by Gleditsch shows that decisions to commit to a landmine ban, by both governments and NSAGs, are mutually dependent.[13] Likewise, Fazal and Kovaev have demonstrated that militarily strong groups seeking international recognition are more likely to commit to a landmine ban.[14,43] Their argument focuses on reputation costs and benefits of compliance to international norms in comparison to the military utility of landmines and other methods of war.

Similarly, rebel leaders may fear criminal indictment for ordering the use of anti-personnel landmines. A report has found that rebel groups are more likely to exert restraint on landmine use in countries where the use of landmines and other similar victim-activated explosive devices has been criminalized by domestic law.[4] The effectiveness of criminal justice in fostering compliance, however, is still debated.[44]

It is worth noting that the aforementioned strategic incentives are interconnected. Political and reputational costs may have direct impact on material support from both the rebel group's constituency and domestic and international audiences, thus compounding to military and economic costs. Similarly, decreased military efficiency could lead to decreased political support.

MORAL INCENTIVES

Restraint may also derive from genuine commitment to humanitarian principles, whether they are based on *humanitarian norms* or the group's own *values, beliefs,* and *traditions*.

Indiscriminate violence is condemned in virtually all cultures, so it is expected that armed groups should avoid unnecessary civilian casualties, unless otherwise justified. Moral obligation has been found to influence decision-making even over material costs and strategic interests.[45]

Sanín and Wood explore the ideology of shaping rebel violence and restraint,[46] and find that specific ideological and religious motivations can further influence increased restraint and compliance to humanitarian norms.[47] The Islamic Emirate of Afghanistan (commonly referred to as the Taliban), for instance, officially considered the use of landmines "an un-Islamic and anti-human act," which "would be punished in accordance with Islamic Law."[48] Similarly, the Revolutionary Proletarian Army-Alex Buncayao Brigade (RPA-ABB) and the Revolutionary Workers' Party of the Philippines issued a joint statement renouncing the use of landmines on ideological grounds.[49]

Restraint may also be driven by interaction with potential victims. In Colombia, rebel groups oftentimes voluntarily marked mine areas or engaged in mine clearance to preserve the communities where they operated. Arguably, genuine interest in protecting civilians from the effects of landmines comes from ethnic and family ties, as well as continued interaction with the communities.[39]

Knowledge and acceptance of IHL may also genuinely lead to restraint on landmine use. Practitioners have found that sustained engagement with NSAGs, in particular through education and awareness of humanitarian norms, constitutes an important step

51

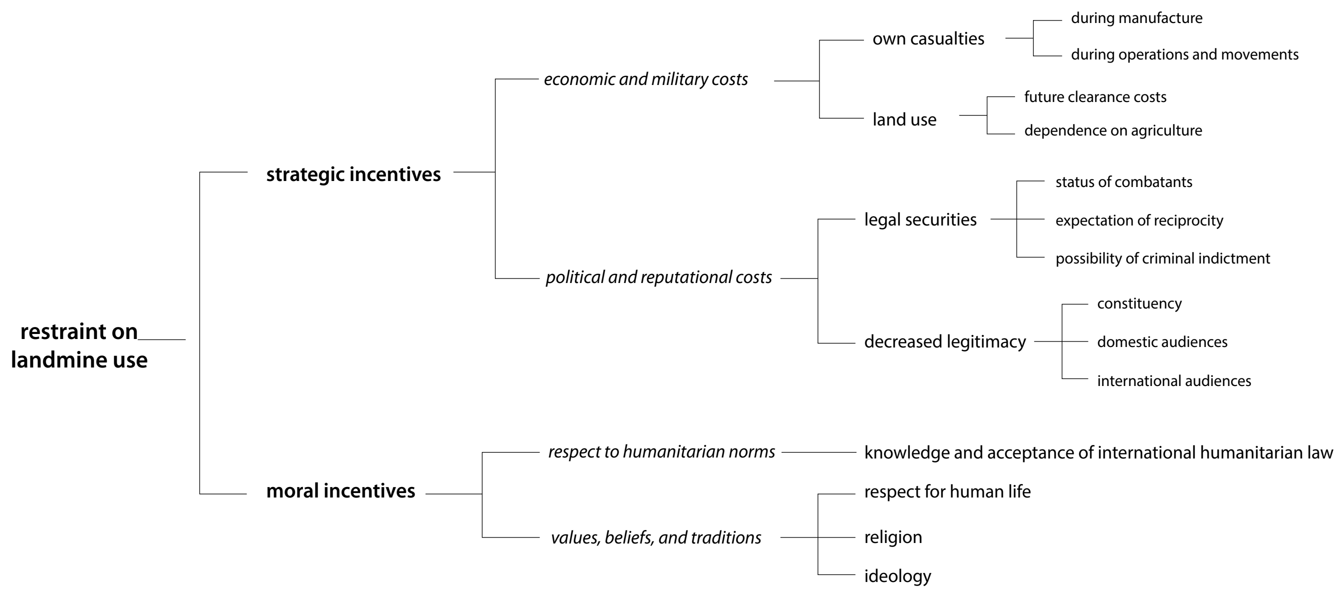

Figure 2. Influencing factors for restraint on landmine use.

towards restraint on landmine use.[50] State and non-state armed actors alike often lack long-term perspective on the humanitarian consequences of their own actions, hence the change in behavior after engaging with human rights and humanitarian norms advocates.[51] In Myanmar, for instance, the Karen National Union, a rebel group and landmine user, agreed to cooperate with mine action organizations after a series of meetings conveying the relevance of international humanitarian law.[50]

FUTURE RESEARCH

In recent years, rebels have been the most prolific users of landmines; however, little has been studied on what drives NSAGs to exercise restraint on landmine use. This study has sought to identify and map possible explanations for this variation. Future research should measure this variable in different conflict contexts and focus on in-depth case studies and process tracing analyses in order to identify the mechanisms at play in each case. Likewise, future propositions should account for interaction effects between the different influencing factors of restraint on landmine use.

Although this article offers no conclusive answer on how to engage rebels in the landmine ban, it has highlighted possible influencing factors leading to restraint. Relevant to policymakers and practitioners, it offers potential entry points and avenues for future dialogue. It remains the task of researchers, policymakers, and practitioners alike to enhance the understanding of rebel motivations to stop using landmines, and, most importantly, act upon them.

See endnotes page 70

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DEVELOPING A SUSTAINABLE NATIONAL TRAINING CAPACITY: NON-TECHNICAL SURVEY TRAINING IN COLOMBIA

By Marc Bonnet, Helen Gray, and Giulia Matassa [GICHD]

In January of 2014, the Geneva International Centre for Humanitarian Demining (GICHD) conducted its first non-technical survey (NTS) training course in Colombia with the objective of enabling participants to plan and conduct NTS. At the time, however, Colombia had the second highest number of landmine accidents in the world,[1] with non-state armed groups (NSAGs) producing explosive ordnance (EO) "mostly in the form of victim-activated improvised explosive devices."[2] Descontamina,[3] the National Mine Action Authority (NMAA), planned for fulfilling its *Anti-Personnel Mine Ban Convention* (APMBC) commitments, and national dialogue was initiated on a *Plan de Choque*, "a plan of action" (i.e., *2014-2016 Humanitarian Demining Action Plan*) that would highlight the role of NTS in assessing the contamination of high-priority areas, which at the time were determined through analysis conducted by the Information Management System for Mine Action (IMSMA).[4]

In its *2014-2016 Humanitarian Demining Action Plan*, the Colombian government presented[5] NTS as the initial step in Colombia's humanitarian demining efforts.[6] Descontamina, also backed by the United Nations Mine Action Service (UNMAS) Colombia,[7] argued that NTS as an initial "intervention" would not only inform technical survey (TS) and clearance but also bring clarity in determining the extent of the country's mine contamination. The *2014-2016 Humanitarian Demining Action Plan* also called for national ownership through increased national investment of humanitarian demining activities, as well as cooperation as part of a collective project to strengthen national capacities.

In line with the International Mine Action Standards (IMAS) Land Release 07.11, Colombia's National Mine Action Standards (NMAS) had recently been updated.[8] Moreover, a growing number of civilian organizations had been accredited and were beginning operations, while an increased number of requests for additional international support were being issued. With the increased need and demand for high quality land release, it became apparent that NTS required investment through training.

THE START OF THE NTS TRAINING PROJECT

At Descontamina's request, GICHD initiated the NTS training project. The initial stages of the training project, between 2014 and 2016, aimed to lay the foundations for increased NTS knowledge, focusing on closing the gap between "what is done in NTS" and "what should be done in NTS," as stipulated by IMAS. The scope of the work was set by the assumptions and knowledge that

- Humanitarian demining activities in 2014 were largely carried out by the Humanitarian Demining Battalion[9] (BIDES at the time, now BRDEH).
- Civilian organizations were being accredited and starting their operations, requiring training for newly-recruited staff.
- Over half of the clearance tasks were completed with no identified EO; thus improving NTS was identified as a priority.

Colombia's expressed need for NTS training was reflected in the *2014-2016 Humanitarian Demining Action Plan*, specifically addressing the need to increase national capacity (understood as the capacity of the BRDEH[10]) and expand humanitarian demining operations by civilian organizations.[11]

Having set the scope and aims of the NTS trainings, informed by national needs, and requests from Descontamina, the GICHD conducted five courses between January 2014 and December 2016. A Colombia-specific Spanish NTS package was developed and adapted from the annual GICHD Global NTS course package. The courses sought to engage mine action personnel to not only promote good practices but also create a space for the sharing of experience and transfer of knowledge. The curriculum for these initial Colombian NTS courses also introduced the train-the-trainer (TTT) component in order to sustain capacity over the long term.

THE NTS TRAINING PROJECT: DEVELOPING A SUSTAINABLE CAPACITY

By the end of 2016, Colombia entered a new political phase with the government signing a peace agreement[12] with the FARC-EP[13] after five decades of internal conflict. Colombian humanitarian demining entities—sixteen civilian organizations[14] and BRDEH—faced a unique opportunity both to reinitiate discussions at the national level on how to address Colombia's aspiration to build a group of national trainers and also to empower national NTS staff to positively contribute to the development of the Colombian humanitarian demining sector. This was led by Descontamina, which re-emphasized its commitment to "build a technical and organizational capacity in humanitarian demining to allow an adequate response and promote Land Release"[15] in its 2016 Action Plan. Similarly, in its *2016-2021 Strategic Plan*, Descontamina acknowledged the need to apply "all reasonable

53

effort to identify, define and remove any contamination or suspicion of APM and UXO."[16]

In answer to solicitations from Descontamina, a preliminary process was drawn up that would not only focus on increasing NTS national capacity but also build a group of national trainers that could lead future national NTS trainings. The development of a sustainable national capacity would allow "National actors [to] take control and command over project/programme activities and … translate [policy] commitment[s] into effective actions"[17] without long-term international and GICHD support.

To promote national ownership and sustainability, the GICHD invested time and effort to ensure course participation across organizations. By proactively enforcing quotas for all organizations, dialogue was ensured among national stakeholders on NTS good practices, requiring gender balance and diversity of experiences and backgrounds, and ensuring Descontamina's involvement in the training itself. Moreover, pre-course tests were used to assess the understanding of NTS and set baselines to, as stipulated in IMAS 06:10 Management of training, "establish objectives for the training…design session plans; and decide on a method for evaluating and testing the training."[18] At the start of the course, trainers and trainees set objectives. These objectives were also used at the end of the course to promote "an after-project vision on how results [could] be sustained"[19] and how impact could be measured. Underlining this was the principle that training did not end once the certificates were handed over but was part of building a "conversation" on good practices across the sector.

This renewed Colombian national capacity project began with the 2014–2016 courses as a means of supporting Colombia's initial need for high-quality land release through effective survey, which truly started in October 2017 with GICHD organizing an NTS course that included all organization and operators. This course was the first to be co-led by a Colombian national trainer with extensive survey experience and promoted rapid learning; continual improvement; and the transfer of knowledge, skills, and attitudes (KSA) required to carry out NTS. With twenty-six participants, including nine women and seventeen men, representing eleven national and international operators and organizations working in Colombia, the foundations were laid for a new cohort of mine action practitioners with the potential of implementing high-quality NTS.

To build on the 2017 NTS course, a NTS course with a TTT component was conducted in July 2018 in Villavicencio, Meta, Colombia. The course participants focused on building KSA to deliver a NTS course, by designing, developing, and preparing lesson plans and practical exercises. Of the eleven participants, five students from five different organizations, including the BRDEH, The HALO Trust, the Colombian Campaign to Ban Landmines (CCCM), Humanity and Inclusion (HI), and Danish Demining Group (DDG), were selected as national trainers.

In an effort to qualify the national trainers, a Colombian external expert organization specializing in adult learning was hired to strengthen their abilities in transferring the TTT and KSA for NTS. It is worth noting that the TTT component builds on strengthening hard skills (technical knowledge) and soft skills (the ability to develop the necessary verbal and non-verbal communication to effectively transmit knowledge that can generate high public recall).

In November 2018, the five national trainers, comprising one woman and four men, led the first fully nationally-led NTS course with the support of a GICHD advisor for internal monitoring. Descontamina's NMAS advisor and the Colombian expert organization conducted external monitoring to assess the trainers' ability to pass on knowledge. Twenty-two participants attended the course—seven women and fifteen men—all of whom successfully passed. In November 2019, the five national trainers independently conducted another NTS course with fifteen participants, comprising four women and eleven men, at the CCCM training grounds in Algeciras, Huila, Colombia, where GICHD involvement was limited to observing the final part of the training.

VALUE OF THE NTS TRAINING PROJECT AND NEXT STEPS

In Colombia, NTS courses have been opportunities to promote good practices and encourage the development of Colombia's national capacity by gradually decreasing external support and increasing Colombian participation in the training process. Six years from the start of initial NTS courses in Colombia, a new generation of NTS surveyors emerged, collectively working to gather high-quality data for efficient and effective land release operations, and strengthening national capacities through the training of new personnel and retraining of existing personnel.

As many trainees become national trainers and trainers within their own organizations, their understanding of NTS increases and is reinforced. As demonstrated in Figure 1, the sum of the number of NTS conducted between 2014 and 2018 varied, and this can be attested to changes in the internal security situation affecting access to various Colombian departments, the implementation of activities, and the change in the number of accredited operators. Nevertheless, the steady decrease in the ratio of suspected hazardous areas (SHAs) registered during NTS is of particular interest as it reaches an all-time low of eight percent in 2018. The percentage of reported SHAs from NTS tasks could result from several factors: an improving NTS methodology due to a higher confidence in identifying evidence that would result in an SHA designation; or the cancellation of previously-reported SHAs, which may be the product of the collaborative NTS project that occurred over the past few years.

As a promoter of cooperation at the national level, the NTS training project has informally created a sense of cooperation in a sector that has at times worked in silos. In the most recent NTS course, many participants claimed that "the only difference between each one of us is the color of our uniform," and regardless of organization, the purpose of each participant's work is the same: to work toward a Colombia free from mines. Increased informal cooperation and dialogue between the trainers and trainees has translated to increased inter-organizational communication, which should also involve Descontamina, as the promoter, regulator, and coordinator of mine action activities within the country.

The five national trainers will require the utmost support from Descontamina. As an international center, the GICHD has invested

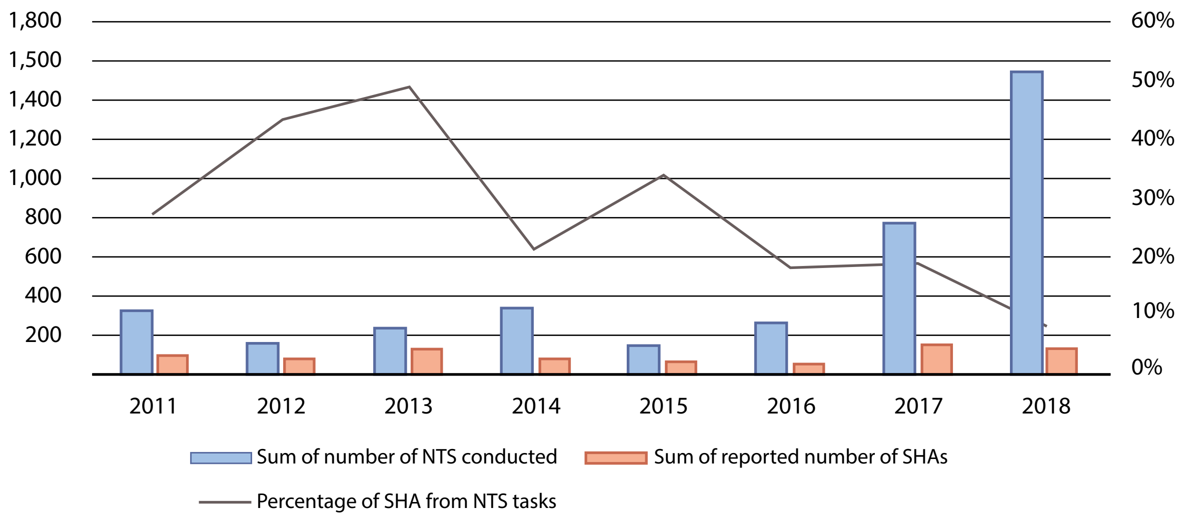

Figure 1. Overview of reported SHAs from NTS tasks from 2011 to 2018.[20]
Figure courtesy of Descontamina and GICHD.

time and expertise in strengthening the individual capacity of the five national trainers and the seventy-five participants (twenty-five women and fifty men), who have been trained since 2017.

GICHD's role will now be to engage with Descontamina to first formalize the NTS national trainers' group by directly engaging in a dialogue with the trainers, and second, to promote them as a new set of national specialists and stakeholders who can contribute to national discussions on NTS. It is key to recognize national trainers at a national level and to develop a joint plan and timeline to define roles, responsibilities, and capacity needs in the handover of the NTS training project. These steps will help ensure that this investment remains longstanding, sustainable, and impactful for the Colombian mine action community. This would in parallel support Colombia's commitment in its *2016-2021 Strategic Plan* for "all reasonable effort to identify, define and remove any contamination or suspicion of APM and UXO."[21]

Having gained the experience of implementing such a project in Colombia over the past six years, it is GICHD's—and by extension the mine action community's—responsibility to promote such TTT projects in other countries and regions, so that national specialists emerge as training and national capacity is developed. This project is also relevant across other subject matters to promote good practices, address national needs, and ensure effective and efficient land release operations.

See endnotes page 71

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Marc Bonnet became the Head of the Operational Efficiency Division at the GICHD in 2015. Previously he was Program Manager at the United Nations Mine Action (UNMAS) office in Colombia and worked in India and South Asia as country director for international NGOs including Humanity and Inclusion and Norwegian People's Aid. Specializing in the management of humanitarian mine action programs, he also worked in Angola, Sri Lanka, and South Lebanon.

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55

AUTOMATED UAS AEROMAGNETIC SURVEYS TO DETECT MBRL UNEXPLODED ORDNANCE

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Unguided Multiple Barrel Rocket Launcher (MBRL) systems are limited-accuracy, high-impact artillery systems meant to deliver barrages of explosive warheads across a wide area of attack. High rates of failure of MBRL rockets on impact and their wide area of ballistic dispersion result in a long-term unexploded ordnance (UXO) concern across large areas where these systems have been deployed. We field tested a newly-developed UAV (unmanned aerial vehicle)-based aeromagnetic platform to remotely detect and identify unexploded 122 mm rockets of the widely-used BM-21 MBRL. We developed an algorithm that allows near real-time analysis, mapping, and interpretations of magnetic datasets in the field and, as a result, rapid identification of anomalies associated with both surfaced and buried MBRL items of UXO. We tested a number of sensor configurations and calibrated the system for optimal signal-to-noise data acquisition over varying site types and in varying environmental conditions. The use of automated surveying allowed us to significantly constrain the search area for UXO removal or in-place destruction. The results of our field trials conclusively demonstrated that implementation of this geophysical system significantly reduces labor and time costs associated with technical assessment of UXO-contaminated sites in post-conflict regions.

INTRODUCTION

Self-propelled MBRL systems have become a familiar sight on the modern battlefields since their widespread use and adaptation during the Second World War. Their ability to deliver a massive barrage of high-explosive rockets over a wide target area and quickly change firing position to avoid counter-battery fire has largely driven their continued use across conflict regions.[1] Perhaps the most widely recognized MBRL is the Soviet-designed BM-21 *Grad* (Hail), capable of firing forty 122 mm rockets in less than a minute (Figure 1A). Since its introduction into service nearly five decades ago, this system has become the most widely used artillery system in the world.[2] Despite their widespread use and perceived effectiveness as a weapon of war, the BM-21 and similar systems are notorious for their relatively low accuracy and high rates of ammunition failure on impact. Specifically, available estimates suggest that MBRL rounds fail to detonate at a rate of about 15 percent,[3] and, depending on the state of ammunition and soil characteristics of the impact site, the "dud rate" may exceed 30 percent.[4] A combination of MBRL systems' high failure rate and large target areas generates a particularly difficult UXO scenario, where UXO contamination occurs over a wide area, the dimensions of which are determined by the ballistic trajectory of the MBRL barrage.

Electromagnetic induction (EMI) and magnetometry surveys remain robust and widely applied tools of landmine and UXO munitions detection and classification in humanitarian demining work. Landmine clearance protocols adapted by demining NGOs and various state demining services largely rely on EMI instruments, which have demonstrated high effectiveness in the detection of large metallic landmines and shallowly-buried UXO.[5] Despite their high sensitivity, traditional EMI surveys are known to be less effective against deeply-buried UXO objects, both in wide-area surveys, and in the presence of metallic debris.[6] Recently, low-altitude total field magnetometer (TFM) surveys conducted from helicopters demonstrated significant potential in their ability to successfully detect areas of landmine and UXO concentrations.[7] Early versions of these systems were composed of three cesium vapors magnetometers with 6 m spacing mounted on one forward and two lateral booms, and carried by a Bell 206 Long Ranger helicopter platform.[8] While demonstrating encouraging results in wide-area UXO detection, an inherent limitation of a helicopter-based system is its high cost of operation and electromagnetic *noise* from the rotor of the aircraft.[9]

In the specific scenario of MBRL-generated UXO, the need for rapid wide-area assessment of UXO presence is particularly important. Traditional methods of UXO detection and remediation are largely inapplicable. Demining surveys based on electromagnetic principles can easily locate the largely metallic MBRL UXO, yet the costs of these surveys over wide areas are largely prohibitive in post-conflict developing countries. Additionally, MBRL rounds may impact the soil at a high angle, penetrating the ground and burying the UXO at a depth beyond the effective range of EMI systems, further complicating their detection and identification. Finally, because contaminated areas inherently contain a mix of MBRL UXO items and fragments of exploded MBRL rounds, large amounts of small metallic debris greatly increase the rate of false flags and further slow the process of wide-area UXO remediation. Attempts to complement or substitute terrestrial time-domain electromagnetics (TDEM) and TFM surveys with other geophysical methods targeting wide-area UXO detection and classification had limited success. Seismic and acoustic methods, as well as surveys focused on gravimetry have had limited applicability and have largely been discarded as viable methodologies of landmine/UXO detection and classification.[10] Likewise, ground penetrating

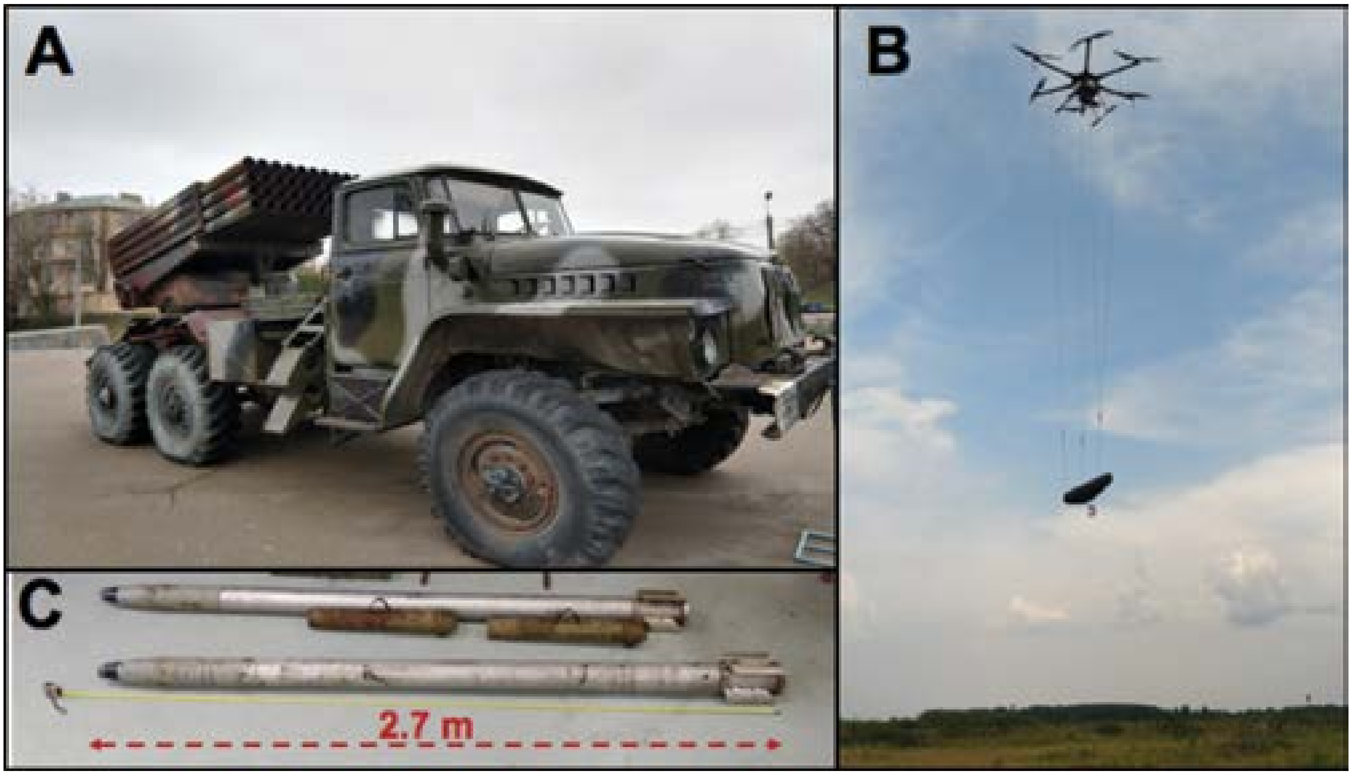

Figure 1. (A) BM-21 MBRL on a truck platform. (B) UMT Cicada-M hybrid UAV hexacopter platform equipped with a suspended Geometrics MFAM magnetometer in a UMT MagPike protective case. (C) BM-21 122 mm rocket with indicated length dimension in red.

radar (GPR) surveys have found limited use in large-area UXO surveys, with direct applicability only in small-scale UXO discrimination and identification surveys.[11]

We present results of a proof-of-concept study focused on developing and field testing a wide-area, UAV-based aeromagnetic survey system to detect unexploded BM-21 122 mm rockets that could be applied to similar and larger-caliber MBRL UXO. Our results indicate that characteristic magnetic anomalies associated with the 122 mm metal casing of the BM-21 MBRL rounds (Figure 1B) register considerably above background levels, both at the surface and up to 10 m aboveground elevation. We further determine that a detection altitude of 3 m is optimal in terms of avoiding low vegetation interference, naturally filtering out clutter noise, while recording meaningful magnetic data at an optimal signal-to-noise ratio. Finally, we demonstrate that this method allows us to distinguish between exploded and unexploded BM-21 rounds, allowing us to direct and prioritize UXO clearance efforts.

UAV-BASED MAGNETIC SURVEY SYSTEM

Advances in UAV technology coupled with successful efforts to miniaturize TFMs allow for a unique opportunity to test a UAV-mounted system for wide-area, high-resolution magnetic surveys targeting UXO detection. Driving this development is the recent commercial availability of lightweight, low-power consumption, laser-pumped atomic TFMs,[12,13] which record the precession frequency of atoms in a magnetic field. An atom's magnetic moment processes around the magnetic field vector, with a frequency proportional to the magnetic field being measured. Atomic precession frequency and, by extension, the magnetic field may be determined to very high precision and sensitivity (pT). Critically, TFMs, such as the recently-released Micro-Fabricated Atomic Magnetometer (MFAM) by Geometrics, record magnetic field magnitude and, unlike vector magnetometers, provide measurements largely insensitive to orientation and vibration. This allows TFMs to be used in aerial geophysical object search surveys, and their small mass allows them to be mounted on commercially-available multirotor UAV platforms.[14]

In parallel with magnetometer sensor miniaturization, commercial multirotor UAVs have become a common sight in recent years. However, most multirotor UAVs remain powered by lithium-ion (LiI) and lithium-polymer (LiPo) batteries, which—due to their weight—provide a restriction on both payload and flight time. Currently, the average flight time for a commercially available hexacopter, with a payload of less than 3 kg, ranges from 15 to 25 minutes, and this time further drops in colder temperatures of operation. This flight duration, while largely acceptable for dense surveying of a confined area,[15] or coarse scanning over a wide area,[16] is prohibitive when wide-area, high-precision scanning is required. Critically, in applications related to landmine/UXO detection, densely-spaced, low-altitude magnetic surveys are needed to provide sufficient sampling to allow for analysis of relatively small metallic objects.

One solution to extend UAV survey time is the use of a hybrid UAV power module with a gas-powered engine powering an electric generator that provides uninterrupted electric power to the UAV. For this study, we relied on the hybrid gas-electric UMT Cicada-M

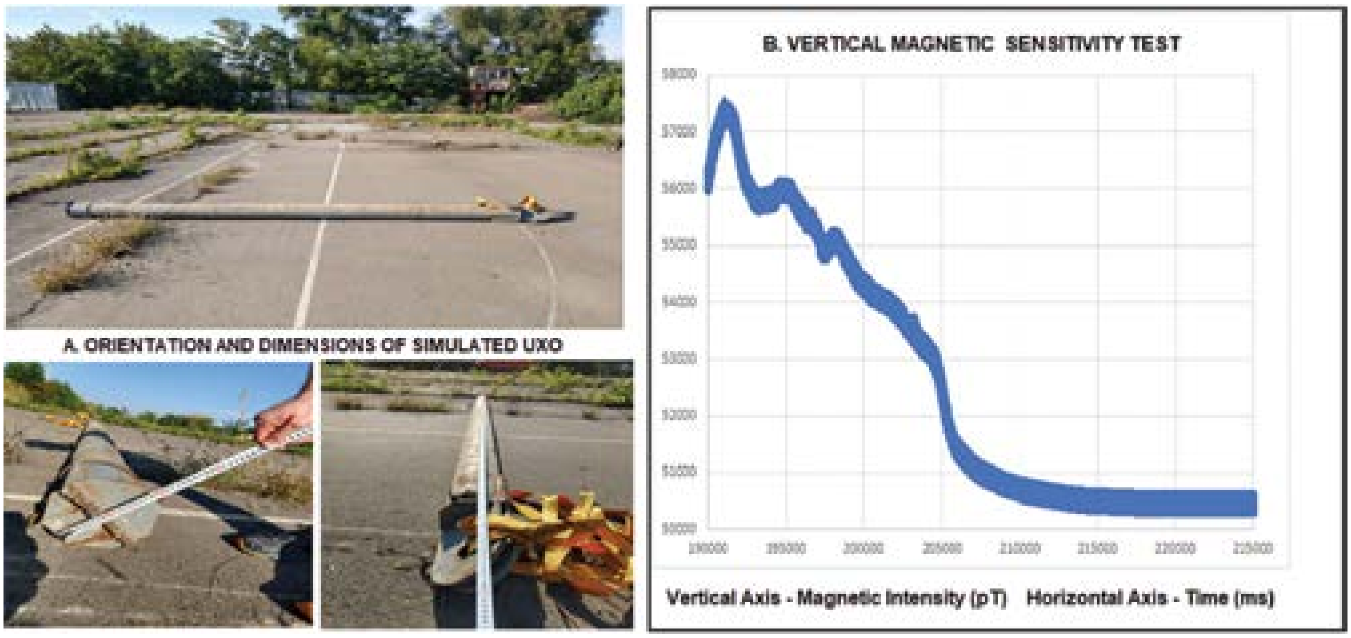

Figure 2. Design **(A)** and results **(B)** of a vertical magnetic sensitivity test.

hexacopter (Figure 1C), manufactured by Ukrainian Multirotor Technologies. Due to the combined 2 kW power module, this UAV is able to stay in the air considerably longer compared to traditional electric drones powered by LiI and LiPo batteries. With a payload of 3 kg, the Cicada-M remains in the air for a maximum flight time of 150 minutes, significantly extending useful survey time needed for high-resolution magnetic acquisition. Critically, the Cicada-M is equipped with RTK GPS modules allowing autonomous, low-altitude data collection along densely-spaced grid lines. Increased instrument sensitivity, coupled with low flight altitudes, higher survey density, and extended flight times offered by the hybrid UAV platform allow identification of anthropogenic targets previously only identifiable in ground magnetometer surveys.

We designed an experimental program to address four central questions, all meant to assess the overall viability of using a hybrid UAV-MFAM platform to conduct wide-area magnetic surveying:

1. Is the MFAM impacted by the magnetic field generated by the hybrid engine or UAV rotor operation?
2. What is the vertical sensitivity of the MFAM to a magnetic anomaly generated by an unexploded BM-21 122 mm rocket and what are the optimal survey parameters for wide-area scanning for this type of UXO?
3. How does the spatial orientation the BM-21 UXO and its depth of burial impact its resolvable magnetic signature?
4. Can an intact, unexploded BM-21 122 mm rocket be discerned from metal debris resulting from the detonation of the same projectile in a blind field trial?

We designed a controlled experiment to address each of these questions and present our results in the next section.

CONTROLLED SITE TRIALS

Prior to beginning targeted surveying, it was necessary to establish the sensitivity of the MFAM unit to the magnetic interference fields generated by the operation of the gas-powered engine and powerful electric rotors of the Cicada-M UAV. We proceeded to measure the minimal vertical separation of the MFAM unit, encased in a protective UMT MagPike ballistic foam case, from the UAV base. For this experiment, as well as all subsequent surveys, sensors of the MFAM were oriented in opposing north-south alternating directions, recording the magnetic field gradient to allow for faster in-field processing of the datasets. We determined that depending on the throttle of the engine, magnetic interference from the engine dissipated beyond the limit of detection at vertical separation of 1.7–2.4 m, with 1.7 m correlating to the lowest engine RPM and 2.4 m correlating to the highest RPM allowed by the engine. For all subsequent trials, we used a vertical separation of 4 m, suspending the MFAM acquisition system using three soft non-magnetic cords attached to the propeller beams of the UMT Cicada-M (Figure 2). In all subsequent trials, we did not witness detectable magnetic interference correlating to engine or rotor operations (regardless of throttle levels), allowing us to conclude that a properly-configured hybrid Cicada-M UAV platform is suitable for accurate magnetic surveying.

In the second experiment, we sought to establish the vertical sensitivity of the UAV-mounted MFAM unit to a magnetic anomaly generated by a single, unexploded BM-21 rocket and define optimal surveying parameters to target this type of UXO. For this experiment, we used a 3-m concrete-filled pipe, similar in mass, length, and metal content to a composite BM-21 122 mm rocket, commonly consisting of the projectile and a metal fragmentation coil wrapped onto the inner wall of the round (Figure 2A). The simulated UXO was oriented east-west on a concrete pad away from other similarly-sized metallic objects. The UAV system carrying the attached MFAM unit was manually guided to the center of the simulated UXO and proceeded to rise vertically at a rate of 1 m/s to a total altitude of 34 m above ground. We

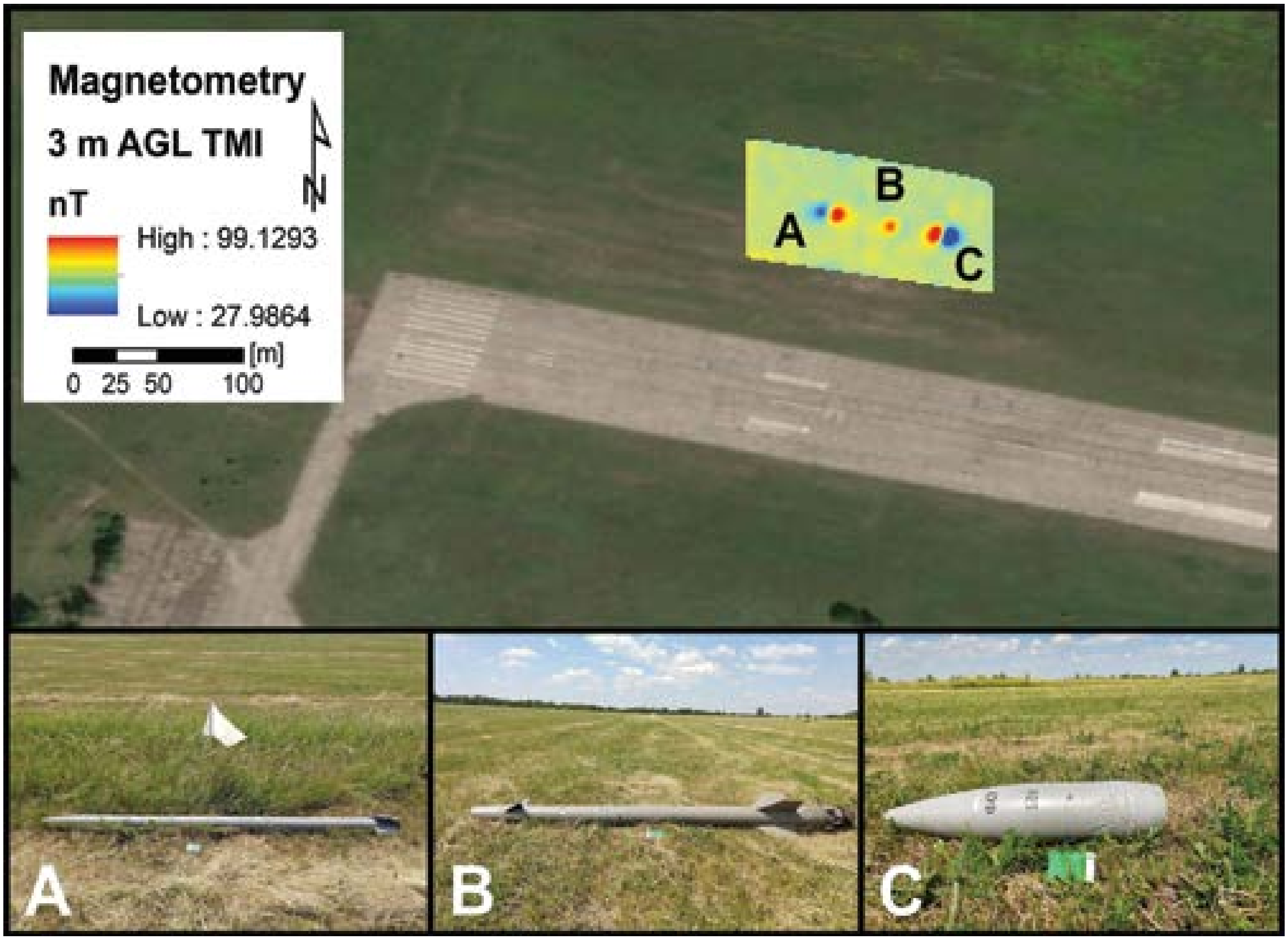

Figure 3. Magnetic intensity map of inert simulated UXO in a controlled field trial site with letters on the map matching the position and type of the planted object. These inert munitions included a BM-21 MBRL 122 mm rocket (A), a SA 22 type anti-aircraft missile (B), and a solid metal core 152 mm artillery shell (C).

present results of the second experiment in Figure 2B, where the horizontal axis represents time and the vertical axis records total magnetic intensity. As anticipated, the magnetic anomaly was most pronounced directly above the simulated UXO, and its intensity dissipated at a geometric progression until fully disappearing at an altitude of about 20 m above ground level (AGL).

Following the vertical sensitivity test, we proceeded to conduct a number of additional UAV flights over a controlled area, seeking to determine optimal survey parameters that allow us to highlight the presence of the simulated BM-21 UXO, while filtering out magnetic noise from metallic debris. Experimentally, we determined that at a tethered sensor altitude of 3 m AGL and flight altitude of 7 m AGL, we could achieve the optimal balance between our ability to resolve a simulated BM-21 UXO and limiting false flags from metallic clutter smaller than the test object. Similarly, we determined that survey spacing of 3 m allows us to consistently identify magnetic anomalies associated with the targeted UXO type. Finally, we identified an optimal traverse speed of 3 m/s, which allows us to both provide high sampling density (MFAM samples at 1,000 samples per second, while the GPS time stamp is placed only every second) and aerodynamic stabilization of the MagPike platform in flight. In sum, we arrived at a 3-3-3 formula for UAV-based aeromagnetic acquisition: 3-m sensor elevation, 3-m traverse spacing, and 3-m/s acquisition speed. The speed of acquisition can be further increased up to 10 m/s if the GPS timestamp frequency is increased to match that of MFAM sampling density.

CONTROLLED FIELD TRIALS

Following controlled site testing and optimization of UAV survey parameters in a relatively small contained area, we proceeded to conduct a series of field trials to determine if automated UAV aeromagnetic surveys over larger areas would successfully detect inert MBRL UXO. We conducted initial controlled field trials on the grounds of Chernihiv Airfield installation in northern Ukraine, where a series of inert training UXO were placed at about 25 m intervals along a linear east-west transect. We tested three types of inert munitions: (*a*) BM-21 MBRL 122 mm rocket, (*b*) SA 22 type anti-aircraft missile, and (*c*) solid metal core 152 mm artillery shell. From this configuration, we sought to determine if we could not only effectively detect but also discriminate MBRL UXO items from similarly sized and shaped non-magnetic UXO items and highly-magnetic but significantly smaller 152 mm artillery projectiles. The setup is presented in Figure 3.

UAV surveys were conducted north-south, perpendicular to the transect in the 3-3-3 configuration as identified in the controlled trials. Raw magnetic data were parsed and de-striped with correct GPS time

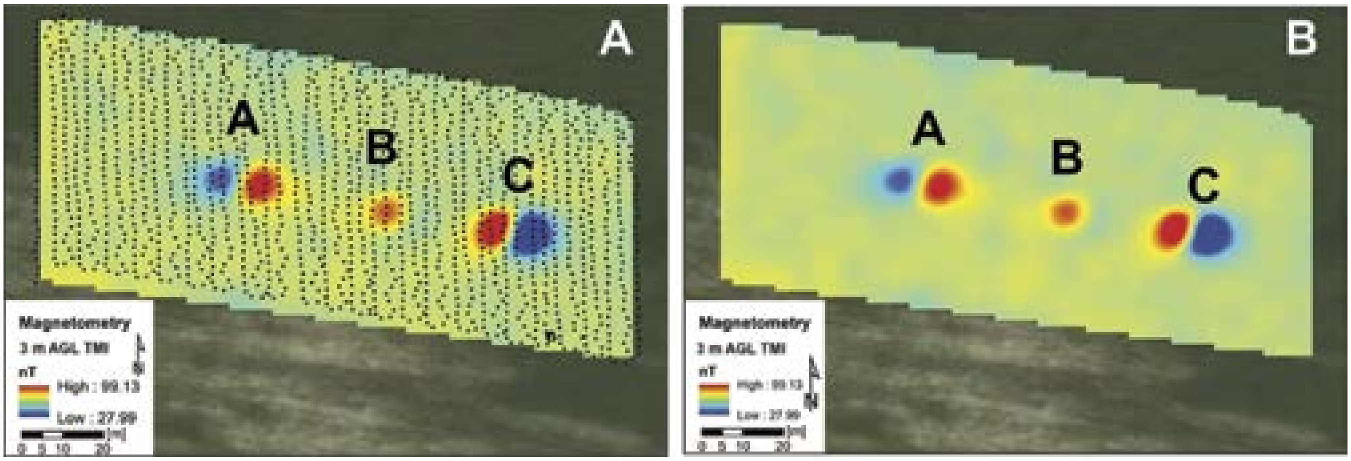

Figure 4. Magnetic intensity maps over controlled site, with small black dots indicating GPS tracks of the conducted north-south UAV flights in (A). Black letters indicate the anomalies associated with simulated UXO objects (B).

markers (Figure 4A). A simple line-leveling technique was then applied to each of the flight lines for every individual flight. This removed the directional interference in the data. Subsequently, the regional total magnetic field for the controlled site was removed. These values were calculated using the International Geomagnetic Reference Field (IGRF) model. The residual total magnetic intensity was plotted using the Kriging Interpolation to turn the values into rasters and create an image of the data. A low-pass convolution filter was then applied to remove image background noise, and the raster color scale and inversion was adjusted to most effectively intensify the magnetic variation in the data, thus clarifying anomalies that represent UXO items. It was then easier to observe magnetic anomalies with a higher confidence that detected UXO items were not false positive errors.

In the processed and mapped datasets, there were three well-defined dipole anomalies: A, B, and C (Figure 4). Anomaly A was associated with the inert BM-21 rocket, anomaly B was associated with the SA-22 inert missile, and anomaly C was associated with the inert metal-core 152 mm artillery projectile. What is immediately obvious is that the largely metal BM-21 (Figure 4A) rocket has a considerably more-intense magnetic signature than a similar-sized and shaped but largely non-magnetic SA-22 inert missile (Figure 4B). Conversely, the metal-core but much smaller 152 mm artillery projectile generated a magnetic intensity anomaly of comparable size to the BM-21 (Figure 4A) rocket.

This result was instructive and helped us calibrate our processing filters to the metal content and size of the BM-21. We also noted that in the presence of massive magnetic UXO items of smaller calibers, there may be false-flag alarms associated with the high magnetic intensity fields generated by such objects. We do note that the inert 152 mm projectile was a solid metal core training projectile without an explosive chamber, which represents a very atypical object to be encountered in the field.

BLIND FIELD TRIALS

Following successful detection of the inert BM-21 rocket in controlled trials, we had a unique opportunity to test the developed survey platform and processing/detection algorithms at a live test site. Specifically, we were presented with an opportunity to survey a small section of the Ukrainian Armed Services Honcharivs'ke MBRL proving grounds. Here, the operators of the grounds identified an area where two MBRL rockets failed to explode on impact—a 220 mm BM-27 *Uragan* (Hurricane) projectile and a 122 mm BM-21 *Grad* projectile.

This area allowed safe access via a reinforced concrete road, which served as a staging and take-off area for the UAV. A survey of the live site was conducted using the same 3-3-3 parameters as previously defined, and the dataset was analyzed relying on the same processing and mapping protocols. The results from the blind test surveys of live, unexploded 122 mm rockets are presented in Figure 5. In the magnetic dataset, we observed two large magnetic anomalies (labeled as A and B in Figure 5). In our initial assessment, informed by results of the controlled trials, we hypothesized that the weaker anomaly is associated with the larger-caliber BM-27 rocket, which despite its larger size contains more non-magnetic aluminum in its design. Consequently, we hypothesized that the larger anomaly B is associated with the BM-21 UXO. Our assessment and the geographical coordinates of the anomalies were relayed to the operators of the testing site, who conducted a visual survey in indicated areas. Anomaly A was immediately identified as a BM-27 rocket, which was submerged at a relatively low angle of impact (Figure 5B). As for anomaly B, the assessment took significantly longer, as there were no visible signs of the UXO at the surface; however, upon closer inspection, the search revealed the tail section of a 95 percent submerged BM-21 rocket, as seen in Figure 5. Critically, the BM-21 rocket's tail section was below ground level and would have been impossible to identify in a wide-area visual survey conducted without constraining the search area.

CONCLUSION

Our results to date indicate that UAV-based high-precision low-altitude aeromagnetic surveys can have a transformative impact in wide-area assessment of regions impacted by MBRL-generated UXO contamination. Having performed calibration experiments. controlled surveys, and live field trials, we arrived at a standardized methodology for wide-area surveying specifically targeting detection

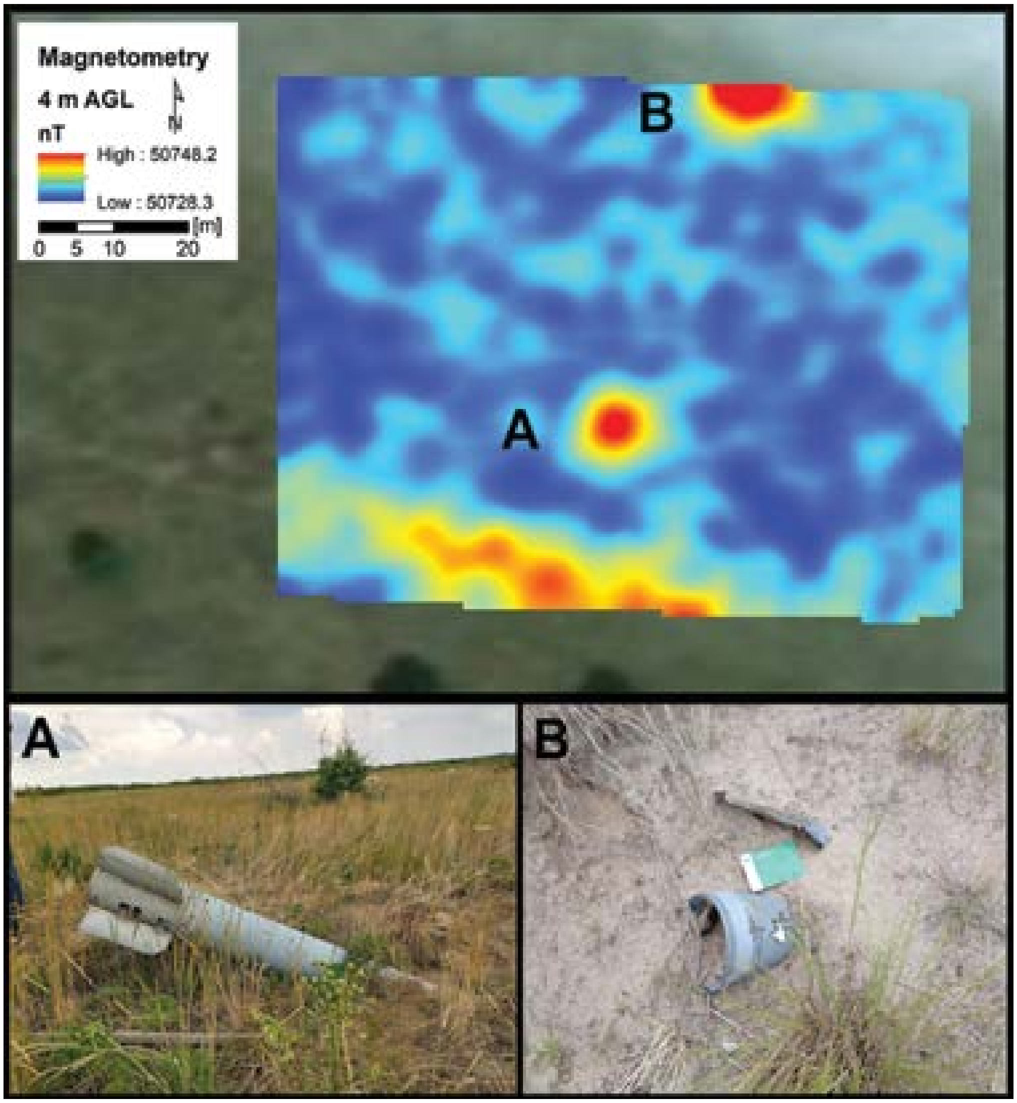

Figure 5. Total magnetic field data at blind test site, with two anomalies associated with UXO objects marked (A) and (B). The concrete road can also clearly be seen to the south in the bottom of the magnetic map, likely because of a large amount of rebar used in its construction.

and identification of the most common 122 mm BM-21 MBRL UXO items. Our blind field trials demonstrated the effectiveness of this system in terms of both assessment accuracy and speed. Critically, we were able to convert aeromagnetic survey datasets to actionable anomaly maps with minimal processing conducted on field-deployed computer systems. Using the current settings of the survey equipment and derived survey air speed and altitude parameters, we can survey 27,000 line meters during a single 150 minutes flight of the hybrid UAV, allowing surveying of a 600 x 600 m area in approximately 11 hours. If, in the future, the sampling rate of the GPS unit is raised to match the sampling frequency of the magnetometer, the survey can be conducted at 10 m/s air speed, and the 600 x 600 m area could be surveyed in 3.5 hours with the same level of accuracy and resulting interpretation confidence.

Successful application of this methodology may be limited in the presence of tall vegetation and may be influenced by site conditions, including host soil geology, presence of metallic debris, infrastructure, and topography, all of which can impact the depth, angle, and successful identification of buried UXO. Perhaps most importantly, impacted areas with vegetation over 10 m tall will force sensor elevation outside the effective range of the survey system. Large, near-surface natural and anthropogenic magnetic anomalies may cause constructive or destructive interference within the magnetic datasets, complicating initial analysis. Finally, highly-variable topography will require additional consideration and accurate terrain contouring by the UAV to maintain constant sensor elevation above ground level.

In the coming months, we hope to conduct additional full-scale trials to further analyze the optimal UAV platform configuration for data collection in the presence of exploded munitions and magnetic clutter. In a previous study, Butler discussed the importance of accounting for background noise that may clutter the data and make the anomalies less distinct in the study of magnetic backgrounds in UXO detection.[17] Our results have been consistent with that of Butler when comparing the noise in seeded and live site data at different heights. Additional inquiry into how various altitudes in terms of distance between magnetic anomalies on the same site affect the optimal height for data collection is also warranted. Additional inquiries should also be focused on the effects of UXO orientation and impact site composition on detection efficiency.

In terms of future development of processing and mapping algorithms, we intend to incorporate additional methods of magnetic noise filtering to improve the resolution of the magnetic dataset. Beyond IGRF, the National Marine Electronics Association (NMEA) Global Navigation Satellite System (GNSS) elevation data could be used to parse data, with additional reduction to the pole (RTP) filtering. This workflow could produce a clearer image and extend the distance range at which discernable data is collected. Finally, as this research effort progresses, we anticipate using the large magnetic datasets to develop an automated algorithm that can be used in machine-assisted data processing, mapping, and analysis similar to our previous research on scatterable landmine detection.[18,19] Toward this end, all raw data from these field trials are openly available at the Open Repository of Binghamton University.[20,21]

While our results to date are specific to the Cicada-M UAV platform equipped with the Geometrics MFAM sensor, it can be reasonably

61

concluded that similar results can be achieved with other UAV and sensor platforms with only slight recalibration of survey design and data processing streams. With UAV platforms further improving in reliability, and magnetometers dropping in size and cost, our study demonstrates the potential for cost-efficient aeromagnetic surveys as a key element in wide-area technical assessment of MBRL-generated UXO contaminated areas.

See endnotes page 71

ACKNOWLEDGEMENTS

Our effort would not have been possible without the support of the engineering, flight operations, and analytics specialists of Ukrainian Multirotor Technologies, in particular Pavlo Kosolapkin, Vitalii Gitchenko, and Anton Smirnov. Additionally, we want to acknowledge the contribution of all personnel of the Geneva International Centre for Humanitarian Demining, the Demining Center of Ukraine, the personnel of the State Emergency Service of Ukraine, and the service members of the Armed Forces of Ukraine, who contributed their time and expertise to this research effort. Also, we are grateful to Binghamton University, in particular Megan Fegley with the First-year Research Immersion program, Wendy Neuberger with the Harpur Edge program, and Olga Petrova with the Office of Entrepreneurship & Innovation Partnerships for supporting this research effort. Finally, the research team would like to personally thank Kyiv-based journalist James Brooke and photographer Sergei Loiko for their insight and motivation that helped guide this project.

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TO WHAT EXTENT COULD THE DEVELOPMENT OF AN AIRBORNE THERMAL-IMAGING DETECTION SYSTEM CONTRIBUTE TO ENHANCED DETECTION?

By Martin Jebens*, Hideyuki Sawada**, Ph.D., Junjie Shen**, and Erik Tollefsen*
*[ICRC] and **[Waseda University, Tokyo]

Over the past two decades, several initiatives that involved research and development on sensor and detection systems have failed to successfully integrate with clearance operations and have not been able to help affected states overcome the humanitarian challenges caused by weapon contamination. Though initial tests were promising, when faced with the reality of the field, the technology often indicates shortcomings.[1]

The terrain, dense vegetation, metal clutter, or other obstacles encountered in humanitarian mine action (HMA) pose challenges often greater than reliable target detection. Therefore, understanding the inherent challenges of a task is paramount when discussing the entry of new technologies into the field of HMA.[2]

Today, most technologies employed in survey or clearance operations fill one function only. The technology performs the intended function very well, but consequently separate intervention with different customized tools will be carried out in sequence, which often comes at the cost of safety, effectiveness, and cost-efficiency.[3]

Ideally, survey and clearance activities should be evidence-based and directed by field assessments and information analyses of a specific geographical area or a task such as a stretch of road or a community. New and developing technologies such as consumer market camera drones, affordable thermo-imaging cameras, and light detection and ranging (LiDAR) systems can be alternatives to other active or passive sensors and tools that can assist survey and clearance operators in establishing evidence of weapon contamination in a variety of scenarios. Such technologies could be elements in a toolbox approach that could help expedite activities without adding costs or impacting operator safety.

Thermal image of a stockmine taken from app. 10 m height. The FLIR Vue Pro sensors was used in an old mine field on the Danish west coast. The same type (not identical) of sensor was used by Nikulin et al. (2018) to detect landmines, and by Casana et al. (2017) to detect archeological objects. Test objects was German WWII stockmines. The beach environment was the same as when the mines were placed in 1944. Stockmines can be found throughout northern Africa. All test objects could be detected with no false alarm rate.

Figure 1. Thermal image of stockmine taken by FLIR Vue Pro.
All graphics courtesy of the authors.

The FLIR Lepton thermal sensor was tested in Geneva, Switzerland. This sensor is integrated in the Mavic 2 Enterprise drone. The resolution was 160 x 120. Many of the test objects could be identified from a 10 m height using this configuration, though only as a footprint and not with clear identification.

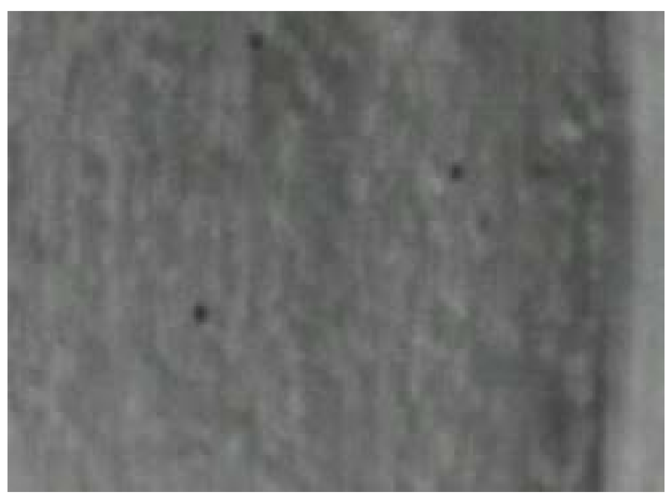

Figure 2. Thermal image metal objects taken by FLIR Lepton thermal sensor.

The InfReC Thermo FLEX F50 was used in a test in Japan. This sensor has a resolution of 240 x 240. The test objects on this image were a combination of wooden replicants of landmines, plastic, and metal objects. In this test the objects were placed both on bare soil and on vegetation. This dataset was used for deep learning (see later paragraphs).

63

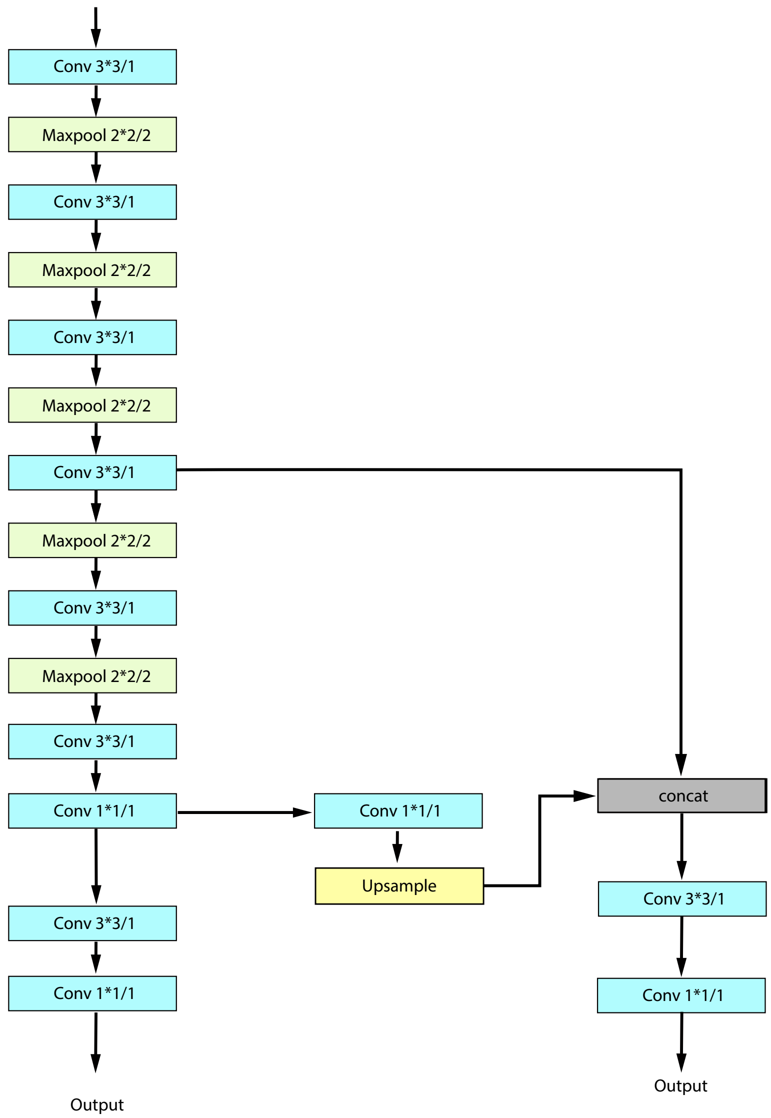

Figure 3. Architecture of tiny-YOLOV3.

The Gordian Knot in survey and clearance involves being able to reach sufficient confidence levels with the technologies and methods employed. As a result, the gold standard of today's operations remain manual operators equipped with metal detectors.

The paradox faced when introducing multi-sensor capability in survey and clearance operations is that while likely to increase the probability of detection (PoD), sensors—e.g., dual sensors combining ground-penetrating radar (GPR) and an electromagnetic interference (EMI) detector—will simultaneously raise the false alarm rate (FAR). This causes operators to have a lack of confidence in the reliability of the alarms observed. Simplified, this means that the increase in the PoD is improving the confidence, while the raised FAR is reducing the confidence levels of a multi-detector system. It is, however, believed that recent developments in deep learning technologies have the potential of helping us overcome this phenomenon. By developing a learning algorithm in the sensor system (thermal-imaging camera), an operator could help reduce the system's FAR on a day-to-day basis. The thermo-imaging technology discussed in this article is clearly not for all conditions, and national authorities and operators should aim to find the most permissible environment for each tool and detector, metal and heat-sensing alike.

In order to bring a functional and affordable concept to operators in the field, close cooperation between operators, research institutions, and manufacturers is vital. In partnership with Waseda University in Tokyo, Japan, the International Committee of the Red Cross (ICRC) has been developing a concept where a thermo-imaging camera mounted on a consumer drone has been used in trials to define a proof-of-concept for use in detection of explosive remnants of war (ERW), and to improve the confidence of detection by using deep learning. Two major Japanese technology consortiums have shown interest in the testing phase, and the test findings show promising results.

THERMAL SENSING

Remote sensing, the use of drones, and deep learning are technologies that are included in the discussions on how technology and innovation can improve humanitarian action and international peacekeeping. The 2016 Agenda for Humanity of the United Nations Secretary General states "that to deliver collective outcomes, the humanitarian sector must promote a strong focus on innovation."[4] These three technologies all have the potential to improve the capacity to assess needs and to monitor changes on the ground. Remote sensing is a relatively inexpensive and quick method to survey large areas of land on a variety of themes, with a low risk for the operators. Due to its relatively (depending on the platform chosen) low environmental footprint and impact on nature, remote-sensing applications support sustainable development and, therefore, are in line with the recommendations included in the Sustainable Development Goals (SDGs) and the Sendai Framework for Disaster Risk Reduction (SFDRR). Remote-sensing data can be collected using different platforms, e.g., satellites, airplanes, drones, or ground-based devices. This project focuses on using a drone-based solution even though combining satellite based and drone-based data can improve the quality of the result.

Thermal sensing is a type of remote sensing that has been tested and assessed as a method for detection of landmines (e.g., OZM-4 and PMD-6) but with no concluding results.[5,6,7] Compared to work done in the 1990s and early 2000s, recent advances in the development of sensors have identified a potential to use them for detection of small objects, as well as conventional (explosive) and chemical, biological, radiological, and nuclear (CBRN) weapons. The size of the object will be a function of the resolution of the thermal sensor and the flight height, hence a M42 explosive submunition can be identified from a flight height between 15 and 20 m.[8-12] Through a joint project, Waseda University and the ICRC wanted to better understand if recent technology developments in thermal sensing could contribute to enhancing operations in this sector and determine whether this technology

Figure 4. Drone with InfReC Thermo FLEX F50.

could eventually be applied to the broader humanitarian sector by assessing the following objective: To what extent could the development of an airborne thermal-imaging detection system contribute to enhance the pace of detection and disposal of mines and ERW?

The challenge in the project was to secure operability between an aerial platform, camera unit, and GPS recorder and to develop a deep-learning system capable of distinguishing patterns of landmines and weapons, including how to exclude homogenous and non-hazardous materials (metal or plastic). The first phase has recently been described successfully by Nikulin et al.[13] and DeSmet et al.,[14] but using deep learning to analyze the data will likely lower the FAR.

One major advantage in using thermal sensors compared to some other sensors is that it is passive. Hence, it only relies on the natural emission of heat energy from different objects. Therefore, thermal sensing is simply the process of converting heat energy into visible images. The principles behind thermal sensing of weapons are relatively simple: due to differences in composition, density, and moisture content, objects on and below the ground absorb, emit, transmit, and reflect thermal-infrared radiation at different rates.[15] Thermal energy is largely a surface phenomenon, and thermal cameras can't "see through" anything. Thermal sensing only measures the passive emission of heat energy from the surface of the nearest objects. However, an object's emission of heat energy can enable us to see buried objects if the soil is able to transfer the energy by conductivity. This will depend on the type of the soil, e.g., the size and shape of mineral grains, chemical composition, and water content. If the object is warmer or colder than the surrounding sediment, it can either cool or heat up the sediment in which it's placed. This can potentially be seen on the soil surface and be detected by the thermal sensor. Likewise, it is possible to detect reworked sediment. In general, heavy vegetation will lower the detection rate because the thermal sensor will receive the passive emission of heat energy from the vegetation covering the objects. However, the vegetation density can change above hidden or buried objects, due to the potential differences in the soil composition caused by the object itself or the rework of sediment. Using thermal sensors, it is possible to assess these differences in vegetation density, and potentially detect patters from landmines.

TESTING

Several tests were performed in Denmark, Japan, and Switzerland. Three different sensors were used during these tests, where the objective was not only the detection of weapons but for a wider use in the humanitarian sector, e.g., to detect human remains or mass burial sites, or to screen for epidemics in refugee camps. In addition, the sensors and drones chosen were commercial off-the-shelf products. Hence, if they can be used for non-technical surveys (NTS) and detection of weapons, it could be a faster, safer, and more cost-effective method. The sensors used included the FLIR Vue Pro, the InfReC Thermo FLEX F50, and the FLIR Lepton thermal sensor. All sensors were mounted on a drone, either a Phantom 3 Professional or the Mavic 2 Enterprise. Whereas sensors are manufactured with a wide range of technical specifications, the specific need should be assessed before choosing the sensor. For example, a thermal sensor used for analyzing the transfer of heat energy in the oceans will likely need a different configuration than the one used for detecting weapons, e.g., different resolution or focal width.

A detailed plan of the flight mission is essential for acquiring high-quality airborne data sets. This is because the user does not have direct control of the sensor, as in ground-based sensing. The flight plan must be based on the technical configuration of the thermal sensor and the aim of the analysis (e.g., size of target or detonation craters). An initial assessment of the area in which the thermal survey will take place is therefore necessary. The flight plan should relate to altitude, speed, frequency of images taken, overlap of images, time of day, and the targets under investigation. Consideration of these factors ensures coverage of the entire area, creation of high-resolution images, and recording of targets with a high enough number of pixels to be used for deep learning. Drones normally have a GPS system with an accuracy of approximately 2 m, depending on the number of satellites available at the time. A differential global positioning system can be used on some drones, which could decrease the accuracy to less than 20 cm.

Place	Time	Drone	Camera	Data Export
Denmark: Danish West Coast. Former WWII minefield	October, November and January (2019/2020)	Phantom 3 Professional	FLIR Sensor resolution: 640x480	16bit tiff
Japan: Tokyo	29 November 2019	Phantom 3 Professional	Nippon Avionics InfReC Thermo FLEX F5 Series Sensor resolution: 240x240	16bit tiff
Schweiz: Versoix	7 January 2020	Mavic 2 Enterprise	FLIR M2ED Thermal Camera Sensor resolution: 160x120	8bit

Table 1. Overview of the equipment used for testing in Japan, Switzerland, and Denmark.

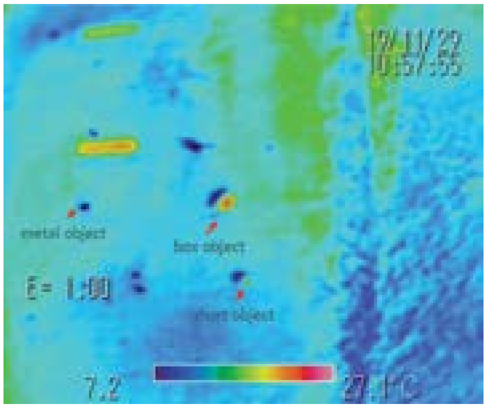

Figure 5a. Metal, box, short objects.

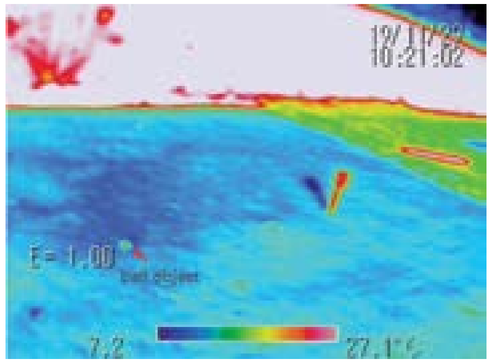

Figure 5b. Ball object.

Figure 5. Different objects in thermal images.

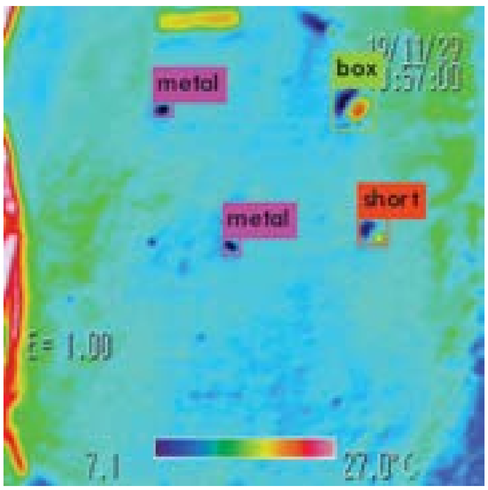

Figure 6a. Prediction result.

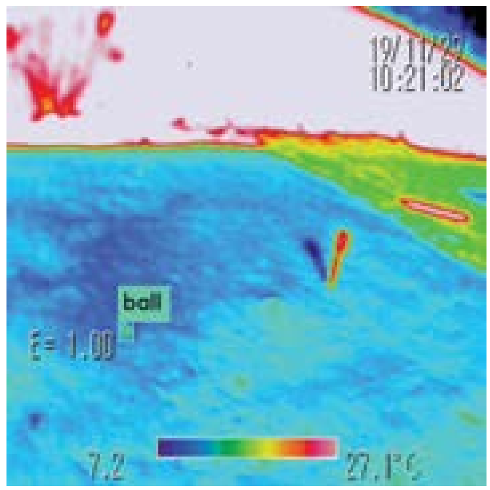

Figure 6b. Prediction result.

The FLIR Vue Pro and the InfReC Thermo FLEX F50 series enables users to capture raw, full-spectrum thermal imagery in 16-bit files that can be used for more advanced analyses. For some thermal sensors it is only possible to export data in 8-bit images. The 8-bit images do not offer the same range of values whereas identification of weapons is difficult. In addition, they do not contain information on the flight path. The FLIR Lepton thermal sensor belongs to the latter category (8-bit) and is therefore less capable of detecting weapons and cannot be used for deep learning. However, it can be advantageous in other types of assessments.

DEEP LEARNING

Deep learning is a technology that can greatly improve HMA. As an important branch of deep learning, object detection algorithms are constantly emerging. Tiny-YOLOV3, the abbreviation of "you only look once," is a popular real-time object detection algorithm. Compared with other objection detection algorithms (R-FCN, SSD), it has a fast detection speed and high accuracy.[16] Because of these advantages, tiny-YOLOV3 is used for detecting the mines in this experiment.

Tiny-YOLOV3 is a fully convolutional neural network, which includes many residual layers, and can help the neural network identify small objects. The tiny-YOLOv3 uses a total of 23 layers, which include the convolutional, maxpool, and residual layers. The architecture of tiny-YOLOV3 is shown in Figure 3.

The convolution layer is the core component of a convolutional neural network. Its role is usually to extract features from an input image. By changing the size of the kernel, the convolution layer can output images with different sizes. This provides researchers with the different features included in images, which in turn will be used for training the neural network.[17]

The maxpool layer downsamples the feature map. The function is to filter the features in the receptive field and extract the most representative features in the region, which can effectively reduce the output feature scale and then reduce the amount of parameters required by the model.[18]

The residual layer does not change the size of the input and output. It is used to deepen the network while controlling the propagation of the gradient, avoiding problems such as gradient dispersion and gradient explosion, and strengthening the training speed.

IMAGE DATA

The requirement for sensors in this project was to produce images having a high enough quality to be used for deep learning. The InfReC Thermo FLEX F50 thermal sensor was chosen because of its superior quality in providing thermal images. The drone system is shown in Figure 4. By using this system, high-quality thermal images were taken in Tokorozawa, Japan, and were used to train the neural network.

The experiment was mainly conducted on humid soil ground, using objects with different shapes and materials as detection targets. These included wooden objects in the shape of boxes and short sticks, plastic objects in the shape of balls, and metal objects placed on the ground. Two examples of thermal images taken by InfRec Thermo FLEX F50 are shown in Figure 5. The colors of particular materials are different in thermal images, which potentially enable researchers to detect various objects by using deep learning

TRAIN AND PREDICTION OF TINY-YOLOV3

As mentioned previously, tiny-YOLOV3 is a popular object detection algorithm with fast speed and high accuracy. This step can improve the resolution of the images, which results in the improvement of the recognition accuracy.

The learning rate was set to 0.001 at first. When the number of training iterations reached 400,000, the learning rate increased to 0.01. The learning rate also changes to 0.1 when the iterations reaches 450,000.

During the training process, each training batch is set to train 64 images. When the number of training batches reaches 500,200 the training process is terminated, and another parameter is related to the threshold. When the intersection over union (IOU) of the prediction grounding box and the ground truth box exceeds 0.5, this prediction value can be regarded as a good prediction. This can further improve the accuracy of the prediction.

After training the IR images, the prediction of the neural network is executed to extract objects. As shown in Figure 6, two metal objects, one box object, and one short object are properly detected. Dummy PMN-2 landmines were used as well. In this test, they were placed above ground. For this reason, the FAR was 0. Currently, testing is taking place on the detection of buried landmines.

NEXT STEPS

The evidence suggests that the method is appropriate in some environments (arid and semi-arid areas that can be encountered on a large scale, globally) and could improve NTS and detection of both buried and non-buried weapons. In addition, the use of thermal sensing is likely to benefit other humanitarian sectors. Several commercial companies in Japan, who also have identified this method as a worthwile technological advancement, have shown interest in using these methods in a wider humanitarian context. It is therefore the opinion of Waseda University and the ICRC Weapon Contamination Unit that the work should be taken into a second phase in which further testing should take place and also look into data fusion.

Data produced by remote sensors has, in the last decade, increased intensely. To cope with this collection of big-data, deep learning has been further developed.[19] Known types of remote sensing in HMA include GPR, gravimetry, electromagnetism, magnetism, etc. These individual data sets contain important information; however, combining the data sets from multiple sources via data fusion can improve the potential value and interpretation.[20,21] Ultimately, data fusion integrates the different information gathered from different sensors mounted on drones, satellites, or ground platforms hereby producing more detailed information. There are many applications for data fusion. Having been applied in sectors like defense and security, it is worth mentioning that data fusion can be used to further improve object detection, recognition, and identification.[22,23]

See endnotes page 71

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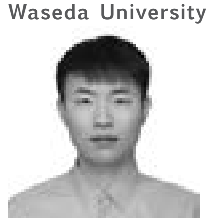

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Erik Tollefsen is the Head of the Weapon Contamination Unit of the ICRC. Prior to working with the ICRC, he worked in the humanitarian mine action sector for nine years with the Geneva International Centre for Humanitarian Demining and seven years with Norwegian People's Aid. In the service of these organizations, Tollefsen carried out missions in Iraq, Iran, Afghanistan, Chile, Ukraine, Vietnam, Laos, Cambodia, Kosovo, Macedonia, Mongolia, Sri Lanka, Angola, and Israel, among others. Prior to this, Tollefsen served in the Norwegian Defence Forces as an Ammunition Technical Officer (ATO). In this capacity, he was posted to UNIFIL (Lebanon) and UNPROFOR (Bosnia and Herzegovina), during the conflict in the early 1990s as an Explosive Ordnance Disposal Officer.

Whither HMA Policy? Linking HMA and Development Assistance by Rasmussen [from page 4]

1. International Campaign to Ban Landmines, "Executive Summary," Landmine Monitor: Toward a Mine-Free World, (1999): 5.
2. The U.S. State Department credits The HALO Trust with coining the term "humanitarian demining" in 1988 as it differentiated military demining in Afghanistan from efforts designed specifically to reduce the ongoing threat to civilians, livelihoods, communities, and public infrastructure in terms of post-war reconstruction. The U.S. later established an inter-agency Humanitarian Demining Program in 1993 (consolidating under one policy roof such programs as Afghanistan 1988, Cambodia 1991, Kuwait 1991, Northern Iraq 1992, Somalia 1991, El Salvador 1993, and Mozambique 1993); in 1997, the United States designated a Special Representative of the President and Secretary of State for Global Humanitarian Demining; and in 1998 the Office of Humanitarian Demining Programs was established in the State Department Bureau of Political-Military Affairs as the lead for HMA, see https://bit.ly/39gYIZg.
3. International Campaign to Ban Landmines, p. 12.
4. "Millennium Development Goals (MDGs)," MDGS.un.org, accessed 25 March 2020, https://bit.ly/2y2URSs.
5. John McArthur, Krista Rasmussen, "How successful were the Millennium Development Goals?" 11 January 2017, https://brook.gs/2zoXbEw.
6. As Stanley Brown, Acting U.S. Deputy Assistant Secretary of State for Political Military Affairs, noted recently: "From a global perspective, the United States has provided over [$3.7] billion in CWD assistance to more than 100 countries since 1993. Over those 26 years, how we prioritized those funds has changed based on foreign policy priorities, the context of international security and post-conflict recovery, and our application of programmatic tools to achieve those objectives," (See "Evolving Funding Models and Donors Remarks." Remarks at Wilton Park Conference, Magaliesburg, South Africa, November 6, 2019. https://www.state.gov/evolving-funding-models-and-donors/). (NB: The figure of $3.7B reflects an upward adjustment based on more current data as reported on page 5 of To Walk the Earth In Safety 2019: the prior quote used $3.4 billion).
   The tension and need to balance between the moral and political imperatives has long been present, going back, for example, to the first U.S. government interagency strategic plan for humanitarian demining, which was prepared at the Directive of President Clinton back in January 1996 in continuation of President Bush's September 1993 National Security Council directive to establish such a body (see https://bit.ly/3auDh88). The plan states that "the purpose of the U.S. Government (USG) humanitarian demining program is to assist selected countries to relieve human suffering and develop an indigenous demining capability while promoting U.S. interests. To achieve program goals, the USG must balance its political, military, technological and economic capabilities with available resources." The point is, how governments fund spending is a political decision around political priorities, and currently the politics suggest greater fiduciary oversight for development assistance and HMA, especially in the face of seemingly competing priorities within and across foreign and domestic policy fronts. Return on investment matters: Evidence matters.
7. According to the U.S. Department of State, the U.S. budget for 2019 was just under $200 million, per planned allocations. It should also be noted that the total amount of U.S. assistance also includes additional munitions related spending of roughly $10.2 million in Defense Department spending as well as $12.2 million from USAID in 2018, and planned amounts for 2019 of approximately $20 million and $12.5 million, respectively. See To Walk the Earth in Safety, 19th Edition, 02 April 2020 https://www.state.gov/reports/to-walk-the-earth-in-safety-2020/.
8. *To Walk the Earth in Safety*, 19th Edition, 02 April 2020.
9. It should be noted that these figures, while reported by the Monitor, may be off a little as some funding was likely spent on minor small arms/light weapons activities and not all went to HMA.
10. A review of the annual *Landmine Monitor* reports for the years 2015 – 2019 indicate that the following six countries received roughly 52% of the total global mine action assistance: Iraq ($469.7M), Afghanistan ($273M), Syria ($191.5M), Lao PDR ($186.4), Cambodia ($121.8M), and Colombia ($118.5M).
11. "Development aid drops in 2018, especially to neediest countries," OECD.org, 10 April 2019, accessed 25 March 2020, https://bit.ly/2xZRxYf (accessed 20 October 2019).
12. "Development aid rises again in 2016," OECD.org, 11 April 2017, accessed 25 March 2020, https://bit.ly/2WGHJN7.
13. *Landmine Monitor* 2019, p. 84, November 2019, https://bit.ly/304Bmoy, accessed 2 June 2020.
14. Other issues have certainly had a positive impact in terms of generating support, such as the ethical argument that mines are indiscriminate weapons, disproportionately affect the poor, have long shelf-lives, and the causal devastation carries generational impact for families and communities. However, casualty and victim reduction results have tended to lead the way.
15. *Landmine Monitor* 2019, p. 32.
16. *Landmine Monitor* 2019, p. 54.
17. The 2019 Report states that in 2018 "at least 3,059 people were killed, and another 3,837 people were injured." This notwithstanding, earlier mine related casualty data from the 2017 Landline Monitor is used in order enable a comparison across a similar time frame with data reflecting typical causes and rates of death in the developing world inasmuch as global health reporting typically has a much longer lag time.
18. The UN's Inter-agency Group for Child Mortality Estimation reported the median of under five child mortality for Sub-Saharan Africa was 82.2 per 1000 live births and 46.4 for South Asia. In contrast, the North American rate was 6.6, while Western Europe was 4.9. See https://childmortality.org/.
19. Lucia Hug, David Sharrow, and Danzhen You, "Levels & Trends in Child Mortality Report 2017," UNICEF, 2017, https://uni.cf/3cMWEKh.
20. Lucia Hug, David Sharrow, and Danzhen You, 2017.
21. WHO, "World malaria report 2017," November 2017, https://bit.ly/3fg7E4t.
22. WHO, "Diarrhoeal disease," 2 May 2017, https://bit.ly/2AlgXkA.
23. Michela Sonego, Maria Chiara Pellegrin, Genevieve Becker, and Marzia Lazzerini, "Risk Factors for Mortality from Acute Lower Respiratory Infections (ALRI) in Children under Five Years of Age in Low and Middle-Income Countries: A Systematic Review and Meta-Analysis of Observational Studies," PLOS One 10, no. 1, (2015), https://bit.ly/2BXr3sF.
24. WHO suggests $1,000 per capita on health care is the needed global average to dramatically improve health-based quality of life. This is, however, well beyond the means of many underdeveloped countries, as half the world's countries spend less than $350 per capita per annum.
25. Without even modeling potential effects, the HMA community can do a better job of breaking down and communicating the impact clearing the aforementioned 149 sq kilometers had on human and community security and well-being, and do so with attention to sustainability, i.e., longitudinal results. For example, a development oriented HMA key performance indicator might include sustainability, measured by an impact assessment at 1 and 3 year intervals of critical but situationally tailored sub-indicators.
26. Fortunately, there is a body of work on which to draw. Two 2004 PRIO publications provide a sufficient base, Preparing the Ground for Peace: Mine action in support of peacebuilding, and the joint publication with UNDP, Reclaiming the Fields of War: Mainstreaming mine action in development. Other representative efforts include the 2008 GICHD report, Linking Mine Action and Development, the 2014 DfID publication Clearing a Path to Development, and the 2016 UNDP report, Mine Action for Sustainable Development. The DFiD publication includes a well thought out theory of change, however, Itad—the firm hired in 2019 to evaluate DfID's Global Mine Action Programme (2018–2021)—stated they struggled to find good empirical research on the causal connections. Itad noted this is partially due to the lack of policy and operational orientations guiding inquiry into the linkage, especially in terms of longitudinal impact. (See https://www.itad.com/article/linking-mine-action-to-development-the-need-for-generating-evidence-of-longer-term-change/.) Clearly more work needs to be done by both the development assistance community and the mine action community, each working toward new, but common middle ground.
   Toward that end, two other documents explore both policy and operational considerations in terms of linking mine action and development—the 2017 joint publication by GICHD and UNDP, Leaving No One Behind: Mine Action and the Sustainable Development Goals, and the latest United Nations Mine Action Strategy 2019–2023. The former maps and explains major direct and indirect linkages between the six primary HMA tasks (land release, victim assistance, gender mainstreaming, risk education, physical security and stockpile management, capacity building, and partnerships) and the 17 SDGs. The UN strategy guideline states clearly that, "Mine action has become a nexus between humanitarian action, peace and security, and development as well as a cornerstone for conflict prevention." The strategy also articulates "the strategic objectives and commitments of the United Nations to address the evolving context and nature of explosive ordnance, and the humanitarian and development challenges these pose." Furthermore, it states that "United Nations activities at both global and national levels to ensure responsiveness to context-specific needs and priorities, while ensuring the integration of mine action across broader humanitarian, human rights, peace and security, and development responses."
27. "IMAS 14.20 Evaluation of the mine risk education programmes and projects," 23 December 2003, accessed 24 March 2020, https://bit.ly/3aiKkRh.
28. "Fourth Review Conference of the States Parties to the *Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction*," APLC/CONF/2019/5, 9 December 2019, https://bit.ly/2YnKuSF.
29. For a good treatment of standardizing and better utilizing this type of KPIs, see Roly Evans and David Hewitson, "Key Performance Indicators and HMA: Time to Standardize?" *The Journal of Conventional Weapons Destruction*, 23, no. 2 (2019): 46–55.
30. *To Walk the Earth in Safety*, 2020.
31. It should be noted that this last concern is often made more challenging for both the HMA and development assistance communities given the demands of working with host country counterpart institutions who at times lack either or both necessary institutional capacity and political will.
32. *To Walk the Earth in Safety*, 2020, p. 37
33. "Leaving no one Behind: Mine Action and the Sustainable Development Goals," GICHD and UNDP, June 2017, accessed 25 March 2020, https://bit.ly/2xjIpxn.
34. In September 2016, Lao PDR did just this, developing their own SDG18: Lives Safe from UXO. In so doing they crosswalk their SDG18 with SDG1: No Poverty, SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 10: Reduced Inequalities, SDG 16: Peace, Justice and Strong Institutions. See https://bit.ly/3alYqlc.
35. Russell Gasser, "Linking Mine Action and Development: Local-level Benefits and Challenges," *The Journal of ERW and Mine Action* 12, no. 2, (2008): 6, accessed 18 December 2016, http://www.jmu.edu/cisr/journal/12.2/editorials/gasser/gasser.shtml.
36. An excellent illustration of this principle is found in the collaboration between the Angolan government, the National Geographic Society, The HALO Trust and the UK government and the British public in terms of decontaminating the Okavango River Basin in Angola. Such collaboration has not only begun to produce results in respect to promoting economically viable use of land, but also river-based transportation, eco-tourism, environmental and scientific research and discovery, as well as being better able to address a range of human and natural threats facing the natural and built environment, wildlife and the Okavango Watershed itself. HALO, long active in Angola, has stepped up its involvement with clearance activity over the past few years in partnership with the National Geographic and its Okavango Wilderness Project. And, the Angolan government has also increased its financial and governance support of this work. The UK government, who has also long supported demining in Angola, has not only increased its recent assistance there, but announced in October 2019 an extension of the model used in Angola to its support of HMA in Zimbabwe. One pillar of such efforts includes the UK government doubling the private contributions made by the British people to the clearance effort, known as "Breaking Boundaries."

Confidence-building through Mine Action on the Korean Peninsula by Rhodes [from page 9]

1. Bill Clinton, "Together with South Korea, we must advance peace talks with North Korea and bridge the cold war's last divide," State of the Union Address, 1997.
2. UN Secretary-General Boutros Boutros-Ghali wrote in a letter to the Foreign Minister of the DPRK dated 24 June 1994 that "the Security Council did not establish the unified command as a subsidiary organ under its control, but merely recommended the creation of such a command, specifying that it be under the authority of the United States."
3. "Korean War," Wikipedia, last modified 9 June 2020. https://bit.ly/2MMFTUE.
4. Armistice Agreement, Volume 1. https://bit.ly/2MLi6EW, paragraph 6.
5. Armistice Agreement, Volume 1. https://bit.ly/2MLi6EW, paragraph 10.
6. "Tall order to transform DMZ minefield into peace zone," The Korea Herald, 26 October 2019.
7. Col. J.Lloyd and Major M.Born, "Demining and Remains Recovery in the DMZ,", (unpublished manuscript, February 2020).
8. UNCSB JSA source.
9. "Battle of White Horse," Wikipedia, last modified 7 April 2020.
10. "Sending States" refers to the sixteen troop-contributing states (in addition to the US) operating under the UN Flag in the Korean War.
11. Sanctuary of Endangered Wildlife, National Institute of Ecology (2018).
12. Even with additional capacity the nature and extent of contamination in the DMZ will require many decades of work. The reference to fifteen years was perhaps restricted to clearance activities in the west of the DMZ only.
13. "Full text of President Moon Jae-in address to the 74th United Nations General Assembly," Yonhap News Agency, 25 September 2019, https://bit.ly/3dUqvlq.
14. "IMAS Compliance Made Simple." Accessed 19 June 2020. http://mineaction.net/.
15. For more details for the databasing of IMAS and compliance tool, see http://mineaction.net/.
16. "Landmine and Cluster Munition Blog, Archived." Accessed 19 May 2020, https://bit.ly/2WL8T59.

Disposal of Explosive Ordnance and Environmental Risk Mitigation. Time for Humanitarian Mine Action to Catch Up? by Evans and Duncan [from page 18]

1. M.R. Walsh. Explosives Residues Resulting from the Detonation of Common Military Munitions: 2002–2006 US Army Corps of Engineers. Engineer Research and Development Center. Cold Regions Research and Engineering Laboratory. February 2007. pg. 1–2.
2. M.R. Walsh, M.E. Walsh, I. Poulin, S. Taylor, & T.A. Douglas. "Energetic Residues from Detonation of Common US Ordnance," *International Journal of Energetic Materials and Chemical Propulsion*. Volume 10. 2011. pg. 169–186.
3. M. Walsh, S. Thiboutot, and B. Gullett. "Characterization of Residues from the Detonation of Insensitive Munitions," SERDP Project ER-2219. November 2017. pg. 3–17.
4. T. Jenkins, C.Vogel. Department of Defense Best Management Practices for Munitions Constituents on Operational Ranges. SERDP 2014. November 2014. pg. 2.
5. C. Ferreira, F. Freire and J. Ribeiro. "Environmental Management of Military Ranges with the Support of a Life-Cycle Assessment Approach," *Global Approach to Environmental Management on Military Training Ranges. University of Cranfield. 2020. pg. 5-1–5-20, T. Temple and M. Ladyman (Eds)*
6. *Directorate of Environmental Remediation Programs*. Environment and Engineering Branch. Department of Defence. Australian Government. Contamination Management Manual. Annex G. Firing Ranges. March 2018.
7. S. Thiboutot, R. Martel, S. Brochu and M. R. Walsh. "Mitigation of the Environmental Footprint of a Munition," *Global Approach to Environmental Management on Military Training Ranges*. University of Cranfield. 2020. pg. 11-1–11-17, T. Temple and M. Ladyman (Eds)
8. H. Craig. "Review of Remediation Technologies for Energetics Contamination in the US," *Global Approach to Environmental Management on Military Training Ranges*. University of Cranfield. 2020. pg. 7-1–7-34. T. Temple and M. Ladyman (Eds).
9. United States of America. Department of Defense. Munitions Demilitarization/Disposal Subgroup and Environmental Subgroup. Joint Ordnance Commanders Group (JOCG). Open

Burning/Open Detonation Units. March 2019. pg. 1.
10. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32000L0060&from=EN
11. https://www.epa.gov/sites/production/files/2017-08/documents/federal-water-pollution-control-act-508full.pdf
12. http://www.legislation.gov.uk/ukpga/1991/57/contents
13. http://www.legislation.gov.uk/ukpga/1990/43/contents
14. nternational Ammunition Technical Guideline 10.10. Demilitarization and destruction of conventional ammunition. UN ODA-2015.
15. The most recent is the Cambodian National Mine Action Standard on Environment but this contains only very general information on chemical contamination from EO. Cambodian Mine Action Standards. Chapter 20. Environmental Management in Mine Action Operations.
16. International Mine Action Standard 07.13, Environmental Management in Mine Action. First Edition. 14 March 2017.
17. For example, Chicala in Maputo Province, 2002. Email. Olaf Juergensen to R.Evans. 19 February 2020.
18. M. Jebens. "Protecting the Environment; Mine Clearance in Skallingen, Denmark", *The Journal of Conventional Weapons Destruction*. Volume 19. Issue.1 Article 11. 2015.
19. https://adrbook.com/en/2017/UN/3288
20. Q3D Elemental Impurities Guidance for Industry. U. S. Department of Health and Human Services Food and Drug Administration Center for Drug Evaluation and Research (CDER) Center for Biologics Evaluation and Research (CBER) September 2015. pg. 42.
21. I. Bortone, F Coulon, W Fawcett-Hirst, M Ladyman and T Temple. "Scientific Principles of Environmental Management," Global Approach to Environmental Management on Military Training Ranges. University of Cranfield. 2020. pg. 1-1–1-3. T. Temple and M. Ladyman (Eds)
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24. The main risk of DU ammunition is the possibility of DU dust inhalation which can lead to kidney damage. Current medical evidence, based on monitoring of a cohort of US veterans exposed, suggest low increased risk of cancer for Gulf War exposures. K. Squibb, M.McDiarmid "Depleted Uranium Exposure and Health Effects in Gulf War Veterans," *Philosophical Transactions of the Royal Society*. March 2006. Volume 361. Issue 1468: pg. 639–648.
25. J. Kalinich, C. Emond and T. Dalton et al. "Embedded Weapons-Grade Tungsten Alloy Shrapnel Rapidly Induces Metastatic High-Grade Rhabdomyosarcomas in F344 Rats," *Environmental Health Perspectives*. Volume 113. Issue 6. June 2005. pg. 729–734.
26. GB van der Voet. "Metals and Health: A Clinical Toxicological Perspective on Tungsten and Review of the Literature.,"*Military Medicine*, Volume 172, Issue 9, September 2007, pg. 1,002–1,005.
27. Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction. Oxford English Dictionary Second Edition. Oxford University Press 2009.
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31. Methaglobin is unable to bind with oxygen. An abnormal amount of methaglobin formation causes the blood to be unable to release oxygen effectively to body tissues.
32. U.S. Environmental Protection Agency (EPA) 40 CFR 261.30.
33. P.B. Tchounwou, C. Newsome, K. Glass, J.A. Centeno, J. Leszczynski, J. Bryant, J. Okoh, A. Ishaque, M. Brower. "Environmental Toxicology and Health Effects Associated with Dinitrotoluene Exposure," *Reviews on Environmental Health*, Volume 18, Issue 3, July 2003, pg. 203–229.
34. https://www.epa.gov/sites/production/files/2016-09/documents/2-4-dinitrotoluene.pdf
35. Environmental Protection Agency. Technical Fact Sheet. RDX. November 2017
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42. T. Jenkins, C.Vogel. "Department of Defense Best Management Practices for Munitions Constituents on Operational Ranges," SERDP 2014. November 2014. pg. 5
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48. M. Walsh et al. "Characterization of PAX-21 Insensitive Munition Detonation Residues," *Propellants, Explosives, Pyrotechnics*. Volume 38. Issue 3. June 2003. pg. 399–409.
49. Environmental Protection Agency. Technical Fact Sheet. Perchlorate. November 2017.
50. S. Thiboutot, R. Martel, S. Brochu and M. R. Walsh. Mitigation of the environmental footprint of a munition. In T. Temple and M. Ladyman (Eds), Global Approach to Environmental Management on Military Training Ranges. University of Cranfield. 2020. pg. 11-2–11-4.
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52. M. Pope, E.Baker. Munitions Safety Information Analysis Centre. Insensitive Munitions Explosive Ordnance Disposal Challenges. International Explosives Safety Symposium San Diego. 2018.
53. P. Brousseau, S.Thiboutot and E.Diaz. "Explosives Ordnance Disposal (EOD) of Insensitive Munitions: Challenges and Solutions," Defence R&D Canada - Valcartier Research Center. 2018. pg. 8.
54. A. Cumming. "Legislative Impact," *Energetic Materials and Munitions Life Cycle Management, Environmental Impact and Demilitarization*. pg. 2–4, A.Cumming and M.Johnson (Eds).
55. J. Wilkinson, D.Watt. "Review of Demilitarisation and Disposal Tecniques for Munitions and related Materials," Munitions Safety Information Management Center. NATO. January 2006. pg. 15.
56. D. Towndrow. "General Introduction to Ammunition Demilitarization," In A.Cumming and M.Johnson (Eds). *Energetic Materials and Munitions Life Cycle Management, Environmental Impact and Demilitization*. pg. 35.
57. "Burning the Bullet. Industrial Demilitarization of Ammunition," *Small Arms Survey* 2013. Chapter 9. pg. 207–209.
58. C. Peffer. T"he Demilitarization of Ammunition," IMPEL Waste & TFS Conference. 16–17 October 2019. pg. 21.

Measuring Behavior Change Resulting from EORE and the Need for Complementary Risk Reduction Activities by Boyd, Kasack, and Nielsen [from page 23]

1. "Combating land-mines in El Salvador," UNICEF, accessed 18 March 2020, https://uni.cf/33t86r9 .
2. EORE is a recent term following on from mine risk education (MRE) that aims to reflect more adequately that EORE efforts comprise other types of explosive ordnance as well. See IMAS 12.10 Mine/ERW Risk Education. For more on explosive ordnance, see IMAS 04.10 Glossary of mine action terms, definitions and abbreviations.
3. "Explosive Ordnance Risk Education, Sector mapping and needs analysis," GICHD 2019, accessed 18 March 2020, https://bit.ly/39XrajQ, page 32 3.4: "The situation is particularly problematic for measuring behaviour change, the long-term aim of EORE, because sustained behaviour change takes place over an extended period of time."
4. REPP surveys are conducted one-on-one with usually one or two persons per EORE session (10–12 questions, lasting 7–10 minutes). The answers provide a good idea as to whether knowledge increased (with a post-interview done right after the EORE session) and, if another interview is conducted three to six months later, how much knowledge was retained. Although answers are not statistically representative, a high number of sessions and a strict protocol for selecting interviewees are measures followed to get best results possible.
5. "Evaluation Report UK Department for International Development SUMMATIVE EVALUATION OF THE DFID GLOBAL MINE ACTION PROGRAMME," Itad, May 2018, accessed 3 April 2020, https://bit.ly/2Rah0oD, page 10.
6. For guidance on FGDs, see OXFAM Research Guidelines 2015, Conducting Focus Groups, or MSF (no year), Le Focus Group, Guide Collecte (en Français).
7. "Focus Group Discussion Guidelines for Communities, Risk Communication and Community Engagement for the New Coronavirus." IFRC. Accessed 6 April 2020. https://uni.cf/2xY452f .
8. Community outreach team is DFID's terminology. MAG prefers the term community liaison (CL), a term that is used at times in this article.
9. "IMAS Mine Risk Education Best Practice Guidebook 1, An Introduction to Mine Risk Education," GICHD/UNICEF 2005, accessed 18 March 2020, https://bit.ly/3b4Frve , page 11.
10. HALO, MAG, and NPA, "Behaviour Change Focus Group Discussion Guidelines, DFID GMAP 2 - Lots 1 And 2," updated as of July 2019.
11. Kayin State is home to one of the world's longest running civil wars between the Myanmar military and ethnic armed groups. Local communities continue to be impacted by heavy militarization in some areas of Kayin State due to the presence of military camps in and around their villages. Many soldiers and former soldiers continue to live in these villages, making landmines and other explosive ordnance a sensitive topic for community liaison teams.
12. Blast fishing or dynamite fishing is the practice of using explosives to stun or kill schools of fish for easy collection. This often illegal practice can be extremely destructive to the surrounding ecosystem, as the explosion often destroys the underlying habitat that supports the fish. The frequently improvised nature of the explosives used means danger for the fishermen as well, with accidents and injuries. (Wikipedia)
13. Risk reduction as defined in IMAS does not reflect the way it is used here in this article. Here, the authors define risk reduction as "actions taken to lessen the probability, negative consequences or both, associated with a particular risk." Mine risk reduction can be achieved by physical measures such as clearance, fencing or marking, or through behavioral changes brought about by MRE.
14. "Fourth Review Conference of the States Parties to the *Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction* APLC/CONF/2019/5," Oslo, 26–29 November 2019 https://bit.ly/3deFC9o , page 36. This action plan for the first time in the Convention's history includes a dedicated chapter on risk education, called Mine risk education and reduction.

Detonating the Media, Raising the Profile of Mine Action by Paul McCann [from page 30]

1. Princess Dianna traveled to Bosnia and Herzegovina for a three-day trip with an American organization, The Landmine Survivors Network, in August 1997 to visit landmine victims.
2. "Diana's Landmine Crusade Put Tories in a Panic," *The Guardian*, accessed 1 April 2020, https://www.theguardian.com/uk/2000/jan/03/monarchy.freedomofinformation.
3. "Angola Unravels: The Rise and Fall of the Lusaka Peace Process," Human Rights Watch, 13 September 1999, accessed 1 April 2020, https://www.hrw.org/report/1999/09/13/angola-unravels/rise-and-fall-lusaka-peace-process.
4. Interview with Adriano Goncalves, Head of International Relations, National Intersectorial Commission for Humanitarian Demining and Assistance (CNIDAH), Geneva, 8 June 2018. http://www.the-monitor.org/en-gb/reports/2019/angola/casualties.aspx#ftn2.
5. Image of Diana, Princess of Wales, body armor, https://collections.royalarmouries.org/object/rac-object-48446.html.
6. The Landmine Free 2025 Campaign membership includes the HALO Trust, Mines Advisory Group, Humanity and Inclusion, Norwegian People's Aid, Association for Aid and Relief Japan, and APOPO. For more information please see https://www.landminefree2025.org.
7. "Mine Action's Fair Share: An Agenda for Change", Landmine Free 2025 campaign, November 2019, accessed 9 April 2020, https://bit.ly/2Rsu9d0, page 5.

A New Approach to Understanding, Achieving, and Demonstrating IMAS Compliance by Hewitson [from page 35]

1. A nonconformity is defined as 'nonfulfillment of a requirement' *(IMAS 07.12 Section 3 Terms, definitions and abbreviations)*
2. www.iso.org/about-us.html
3. There are a great many such organizations around the world: over one million certified against ISO 9001 alone.
4. For example, In the UK it is UKAS, in Vietnam it is STAMEQ, in Algeria it is IANOR and so on. A full list of members and accrediting bodies can be found at www.iso.org/members
5. For example: The organization shall determine external and internal issues that are relevant to its purpose and its strategic direction and that affect its ability to achieve the intended result(s) of its quality management system. *(ISO 9001:2015, 4.1 Understanding the organization and its context)*
6. For example: The organization should evaluate its existing risk management practices and processes, evaluate any gaps and address those gaps within the framework. *(ISO 31000:2018 Risk management – Guidelines, section 5.1 Framework, general)*
7. In this case the text is taken from ISO 9001:2015(E) Introduction, 0.1 general, but similar text is found in other ISO standards.
8. In the English edition of ISO 9001:2015 (Quality management systems – Requirements) for example, 'shall' appears 129 times, 'should' only twice, and then in the forward and explanatory introduction only. In ISO 31000:2018 (Risk management – guidelines), which provides guidance and is not a standard against which an organization can be certified, 'shall' appears once, in explanatory text, and 'should' 69 times in the main body of the document.
9. Although 'can' is used in this way in the International Ammunition Technical Guidelines (IATGs).
10. While the role of the Technical Notes for Mine Action (TNMAs) is to explain how to comply with some specific aspects of IMAS, as well as to provide other information of a technical

69

nature, there is not such a clear distinction within the IMAS system between documents that contain exclusively requirements and those that provide supporting guidance.

11. The normative elements are those 'shall', 'should' and 'may' statements found within the main body of each standard (which is always 'normative') and in a small number of normative annexes. Most annexes to IMAS, other than the references to other standards, are 'informative'. IMAS 01.10 is unusual in that it has several normative annexes covering fundamental aspects of the IMAS system such as the IMAS management structure, terms of reference for the IMAS Review Board and the procedure for amending or developing an IMAS.
12. Such as the extensive recommendations in Annex B to IMAS 07.40 on the conduct of site monitoring visits, or Annex C to IMAS 09.31 which provides recommendations on working practices and management oversight during IEDD operations.

The Lethality Index: Re-conceptualizing IED Clearance Planning and Delivery in Iraq by Wilkinson [from page 38]

1. While UNMAS has a number for Iraq, and it's relevant, the same question still applies to other environments. For further information, please see *Landmine Monitor* 2019 Report, accessed 15 June 2020, http://www.the-monitor.org/media/3074086/Landmine-Monitor-2019-Report-Final.pdf, p. 88: in 2018, Iraq received $116.4M in international support; p.89: "Iraq was the recipient with the largest decrease, receiving $86.9M less than in 2017".
2. "IEDs and Urban Clearance Variables in Mosul: Defining Complex Environments," *The Journal of Conventional Weapons Destruction*, Vol. 23, Issue 2, pp. 13-20, July, 2019.
3. ISIS carries out (an average of) 60 attacks a month in Iraq according to Masrour Barzani, Prime Minister, Kurdistan Regional Government, "The Inconvenient Truth About ISIS," The Atlantic, February 14, 2020.
4. From the start of operations in August 2016 through December 2019, UNMAS Iraq teams alone cleared more than 39,800 explosive remnants of war, including more than 3,900 IEDs including suicide vests and IED main charges from Iraq's liberated areas. UNMAS Iraq data
5. International Campaign to Ban Landmines, *Landmine Monitor* 2019 Report, November 2019, accessed 8 June 2020. http://www.the-monitor.org/media/3074086/Landmine-Monitor-2019-Report-Final.pdf
6. The term "explosive hazards" is interpreted here includes: mines, cluster munitions, unexploded ordnance, abandoned ordnance, booby traps, improvised explosive devices and other devices as defined by CCW APII = Convention on Certain Weapons Amended Protocol II (CCW APII).
7. iMMAP data, August 2018
8. International Campaign to Ban Landmines, *Landmine Monitor* 2019 Report, November 2019, accessed 15 June 2020. http://www.the-monitor.org/media/3074086/Landmine-Monitor-2019-Report-Final.pdf. p. 28.
9. World Bank, 2018. Iraq Reconstruction & Investment: Damage and Needs Assessment of Affected Governorates. [pdf] World Bank. Retrieved from:
10. National Iraqi News Agency (NINA), 13th April 2020 – Story quotes police sources investigating deaths of two young Yazidi men killed and four others wounded by an unspecified ISIS explosive device hidden in an abandoned house in Al-Qahtaniyah district, west Mosul.
11. Of 111 confirmed and suspected areas in Ninewa governate contaminated with IEDs, 75 percent were in agricultural land in Al-Hamdaniya, 85 percent in Baashiqa, and 100 percent in Takaif. Norwegian People's Aid Non-Technical Survey Results, 2018 and 201
12. "Rural Areas in Ninewa: Legacies of Conflict on Rural Economies and Communities in Sinjar and Ninewa plains," a report, International Organization for Migration (IOM), 2019, p 5
13. "IED Threat Consistency, Predictability Suggest a 'Simple' Model for Clearance," *Journal of Conventional Weapons Destruction*, Vol. 23, Issue 2, pp. 7-12, July, 2019
14. "IEDs and Urban Clearance Variables in Mosul: Defining Complex Environments," *Journal of Conventional Weapons Destruction*, Vol. 23, Issue 2, pp. 13-20, July, 2019
15. "IED Threat Consistency, Predictability Suggest a 'Simple' Model for Clearance," *Journal of Conventional Weapons Destruction*, Vol. 23, Issue 2, pp. 7-12, July, 2019
16. "IEDs and Urban Clearance Variables in Mosul: Defining Complex Environments," *Journal of Conventional Weapons Destruction*, Vol. 23, Issue 2, pp. 13-20, July, 2019
17. 10 deceased victims recovered from debris, west Mosul, 26th January; United Nations Security Service Report, 27th January 2020
18. "IEDs and Urban Clearance Variables in Mosul: Defining Complex Environments," *Journal of Conventional Weapons Destruction*, Vol. 23, Issue 2, pp. 13-20, July, 2019
19. "Connecting the dots: The Pace of IED Clearance Seen as Key Factor to Safe Return of 1.6 Million Displaced Iraqis," *Counter-IED Report*, Autumn, 2019, pp 17-22
20. Vladimir Voronkov, Undersecretary-General, U.N. Office of Counter-Terrorism, United Press International, 23rd August, 2019: "(ISIS) continues to evolve into a covert network" following a pattern from 2017 whereby ISIS "insurgency activity reportedly designed to prevent normalization and reconstruction efforts continue.
21. In January 2020, UNMAS Iraq began supplementing its operational data tracking work days lost due to various factors, including security, for each of three clearance teams deployed across Iraq. For the month of January, the three teams reported a combined total of 42 actual work days versus 59 potential work days, with work day losses attributable to weather (-2), manning (-3), non-operational reasons (-5) and security (-8). Most significant, all work day losses attributable to security affected the same team, a clear indicator of ISIS focus in that team's area of operation, reducing that team's cost-effectiveness by 66 percent.
22. Iraq Bi-Weekly Estimate, 2020-081, UN Iraq Joint Analysis Unit, 21 January, 2020, p.8
23. UNDSS estimates 2019 strength at between 4,000 to 10,000
24. "Isis in Iraq: Militants 'getting stronger again'," By Orla Guerin, BBC News, Northern Iraq, 23 December 2019, quoting unnamed Kurdish intelligence officials.
25. Iraq Bi-Weekly Estimate, 2019-080, UN Iraq Joint Analysis Unit, 31 December, 2019, p.6, revised to 4,462 as of 20 April 2020
26. ISIS is believed to have decentralised its command and control structure and has increased the number of operational sectors in Iraq from four to ten, with each operational sector self-financed through illegal economic activities, such as extortion. Courtesy UN Joint Analysis Unit, 20 April 2020'
27. Infographic covers a period approximately from September 21, 2017 to January 31st, 2020. Estimate courtesy Saif Al-Tatooz, UNMAS Iraq. For most of 2019, open source data indicated a larger number of ISIL incidents, when compared with ISIL's Amaq New Agency data until September of 2019. GoI sources usually admit to approximately 23 percent of the attacks claimed by ISIL. The discrepancy in reporting ISIL incidents can be attributed to the confusion of mixing security incidents with ISIL attacks. Courtesy UN Joint Analysis Unit
28. For a more detailed analysis of 'cost benefit analysis' and reporting metrics, see, for example, Eliot, G. and Harris, G., A Cost Benefit Analysis of Landmine Clearance in Mozambique, Development Southern Africa, Volume 18, No. 5, pp. 625 - 633
29. Defined as a system of numbers used for comparing values of things that change according to each other or a fixed standard, Cambridge Dictionary, Cambridge University Press, 2020
30. See: Wilkinson, M., IED Threat Consistency and Predictability in Fallujah: A Simple Model for Clearance, & IEDs and Urban Clearance Variables in Mosul: Defining Complex Environments, *The Journal of Conventional Weapons Destruction*, Issue 23, No. 2 (July 2019), pp. 7 – 12 and 13 – 18.
31. See, for example: Bibby, P R, Shepherd, JW, 2004, 'Developing a New Classification of Urban and Rural Areas for Policy Purposes – the Methodology' Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137655/ruralurban-definition-
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33. Courtesy of Nathan Williams, Operations Planning Officer, UNMAS Iraq.
34. Evans, Roly and Hewitson, David (2019) Key Performance Indicators and HMA: Time to Standardize?, *Journal of Conventional Weapons Destruction*: Vol. 23 (2019) Issue 2, pp. 48 - 49

Seventh Mine Action Technology Workshop: A Space for Innovation by Khanyan and Cruz [from page 45]

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2. Podest, Erika. "Basics of Synthetic Aperture Radar (SAR)." NASA, November, 2017. https://go.nasa.gov/35UlNAH.
3. Imperial College London. Space and Atmospheric Physics, Fluxgate Magnetometers. https://bit.ly/35QtkjU.

Understanding the Logic of Rebel Restraint on Landmine Use by Garbino [from page 48]

1. This article is based on the author's master's thesis, entitled "Rebels Against Mines? Explaining rebel restraint on landmine use", presented at the Depart-ment of Peace and Conflict Research, Uppsala University, on 3 June 2019. http://uu.diva-portal.org/smash/record.jsf?pid=diva2%3A1321893&dswid=7849
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3. Ann-Kristin Sjöberg, "The Involvement of Armed Non-State Actors in the Landmine Problem: A Call for Action," in Nairobi Summit on a Mine Free World (Nairobi Summit on a Mine Free World, Nairobi, Kenya: Geneva Call, 2004), 35.
4. Ann-Kristin Sjöberg, "Volume I: A Global Report Profiling NSAS and Their Use, Acquisition, Production, Transfer and Stockpiling of Landmines," *Armed Non-State Actors and Landmines* (Geneva, Switzerland: Geneva Call the Geneva Graduate Institute's Program for the Study of International Organization(s), Oc-tober 2005). To the author's knowledge, this is the latest compiled publication on landmine use by non-state armed group.
5. Ann-Kristin Sjöberg, "Armed Non-State Actors: The Main Users of the 'Poor Man's Weapon,'" *Journal of Mine Action* 10, no. 1 (August 2006): 73–75.
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Developing a Sustainable National Training Capacity: Non-Technical Survey Training in Colombia by Bonnet, Gray, and Matassa [from page 53]

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Automated UAS Aeromagnetic Surveys to Detect MBRL Unexploded Ordnance by Nikulin, de Smet, Puliaiev, Zhurakhov, Fasullo, Chen, Spiegel, and Cappuccio [from page 56]

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71

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Editorial: Empowering Local Capacity in Mine Action

With explosive hazards contamination persisting in spite of dwindling funding opportunities, sustainable solutions are becoming increasingly more important. Similarly, creating mine action programs and centers that can be relied upon to pick up the reigns after foreign clearance organizations and contractors have left is of paramount importance. What lessons learned can the community share in regards to building national capacity and employing locals to continue operations after projects have concluded?

HMA and COVID-19

The world is facing an unprecedented global crisis caused by COVID-19. Already struggling with nonexistent or insufficient essential services and infrastructure, unsanitary conditions, and vulnerable populations, post-conflict environments are at risk of facing even greater challenges compounded by COVID-19. How have HMA organizations responded to the pandemic and in what ways have they adapted their operations both in and out of the field? In what ways have organizations leveraged their in-country assets (or resources) to assist regional authorities and local communities? What does the future look like for HMA operations during a global pandemic, what challenges does the sector anticipate facing, and how can we better adapt to these new circumstances?

We are accepting submissions on this topic for the Fall edition of *The Journal* through July 31.

Balkans

Organizations working in Bosnia and Herzegovina, Croatia, Serbia, Kosovo, and Montenegro are encouraged to submit on their current programs, challenges, and successes.

Environmental Concerns of Explosives

War and conflict have obvious negative effects on the human communities in which they occur, but the effects that ammunition and explosives can have on the environment are less evident. How does explosive contamination affect the environment, how do explosive detonations affect the physical and chemical properties of ground soils, and what measures can MA operators take to reduce these effects?

HMA and CWD in the Context of IDPs and Migration

How can HMA/CWD programs better adapt to the return of IDPs, and how are countries/organizations addressing migration as it occurs across mined borders and contaminated areas?

Demining in Dense Terrain

Freedom of movement remains restricted in some forest and jungle areas of the Balkans, Ukraine, and Colombia, endangering human life, damaging the ecosystem, and increasing the risk of fires. The Journal seeks submissions from organizations operating in these areas.

Management Information Systems and/or On-Site Analytical Tools

Management information systems differ from information management systems in that they are used for decision making as opposed to information storage. How are organizations using decision-assisting technologies to analyze and interpret data and efficiently allocating resources to the field?

Research and Development

The Journal of Conventional Weapons Destruction seeks research and development (R&D) articles. All technical articles on **current equipment, technology, trends, and developments** in the field of mine action and CWD will be considered. Commercial companies, NGOs, and researchers are encouraged to submit. R&D submissions are reviewed by subject-matter experts in single blind peer reviews, where authors receive reviewer feedback anonymously and articles undergo an iterative approval process before being published. Reviewers approve articles for publication, suggest revisions, or reject articles for publication.