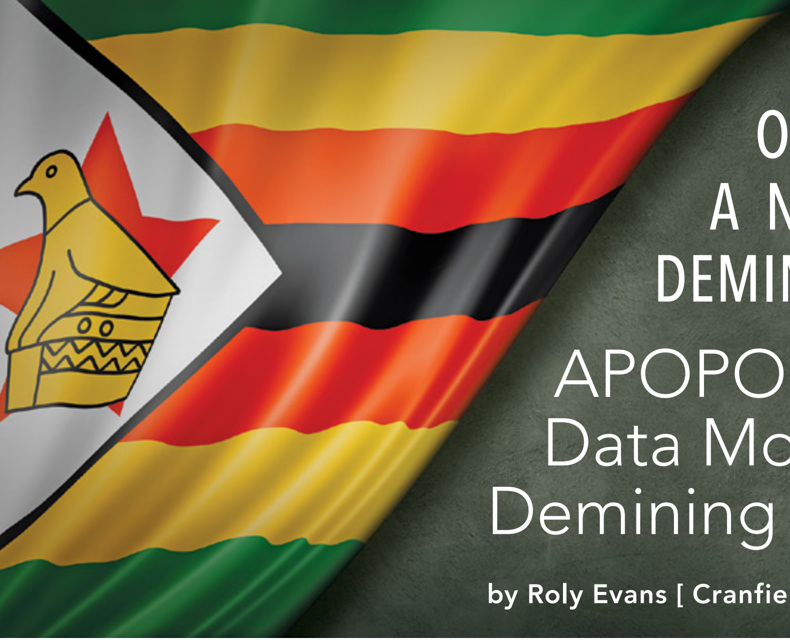

OPERATIONAL DATA: A NEW APPROACH TO DEMINING DATA COLLECTION

APOPO's Use of the Clearance Data Model to Improve Manual Demining Operations in Zimbabwe

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In September 2023, APOPO started a field trial of a new approach to operation data for demining operations. Titled the Clearance Data Model (CDM), the approach involved collecting sixty-six data attributes for each mine found. Crucially, this vastly expanded data collection entailed making the mine, rather than the area, the unit of data against which attributes are recorded. The results are the most detailed dataset recorded for a demining task. They enable significant improvement in the understanding of operations, along with the ability to conduct semi-quantitative demining risk assessments.

> **The end of all our exploring will be to arrive where we started and know the place for the first time.**
>
> **~ T. S. Eliot.**

The trial lasted until March 2024 and APOPO Zimbabwe subsequently revised its data collection methods, incorporating the CDM into daily reporting while further exploring what is practicably possible in data collection in terms of balancing the time taken with the need for the team leader to manage and monitor a manual clearance team of six deminers. From April until 6 December 2024, a further 1,735 mines were recorded using the CDM. The results continue to clearly show that it is entirely practical to record extensive detail concerning each mine found in the field. It is also desirable, given the benefits of such expanded data collection has not only for risk management but also for daily operations and quality management. Each mine is not seen as a data burden but as a data opportunity that, together with other mines, enables us to really understand what we are clearing, how we are clearing it, and in what conditions.

OPERATIONAL DATA

This new approach to demining operations was based on the concept of operational data. That is data collected by field staff for field staff, with the understanding that gathering data relevant for them actively helps them to do their jobs. There has been some progress in this direction already. The Conventional Explosive Ordnance Disposal[1] (EOD) and Improvised Explosive Device Disposal[2] (IEDD) competencies, revised in 2022 and 2019 respectively, included for the first time competencies on collecting data for the purposes of risk or threat assessment and improving operational practice. This was a departure from International Mine Action Standards (IMAS) 05.10 on Information Management that made no link between data collection in the field and risk management. Notably the terms risk management or risk assessment do not even appear in IMAS 05.10.[3]

The operational data approach also emphasized the importance of access to data for field personnel. Staff are more likely to be conscientious when filling in reporting forms if they actively use the data they gather. There was a determination that field staff would have access to and use the data they collect. Key to the operational data approach was the design of data collection forms by field staff, with decisions on what data to include taken by them. Information management staff played an essential enabling role without assuming that they know better than operations staff what data should be collected. There was a clear aim to move away from forms designed by non-operational staff that often capture redundant data that makes little sense to the demining staff completing it in the field. The dashboards that reflect the data were built for staff to not only have an enhanced view of their own operations, but also to channel data into bespoke operational risk assessments.

An APOPO manual deminer prepares their equipment before completing their final demining session of the day. The deminers used Minelab F3s with black endcaps to find R2M2 minimum metal anti-personnel blast mines. The mines were placed in a pattern and fortunately there was limited metal contamination of the ground, which also greatly assisted the efficiency of demining.

All images courtesy of APOPO.

A QUESTION OF TIME

Why, to date, do mine action operators, and perhaps also the military, only collect limited or no data about individual mines found in the field? One possible explanation is that it was believed the time required to do so was prohibitive. Another might be that such data was of limited value in any case. The field trial in Zimbabwe has shown that the collection of over sixty-six data attributes for each mine found is entirely practical for team leaders to record. With a little practice each form took on average four minutes to complete, and team leaders rarely completed more than six forms daily (a period of six to seven hours on site). For up to thirty-six deminers split between six teams, anywhere between eight and twenty-three mines might be discovered in a day. These were recorded without any disruption to demining productivity, not least because team leaders filled in the forms while deminers continued clearing their lanes much as before, with the only difference being that they noted down key details, such as how long it took them to excavate a mine. Ultimately the Zimbabwe field trial showed that time is not a valid reason for not collecting more data for each individual mine.

At present, APOPO team leaders on sites in Zimbabwe now devote 20 percent of their time to data collection, more than during the trial. Since April 2024, APOPO's system has gathered 20,000 data points per day, which is the equivalent of more than 4,000,000 data points per year. This is made possible due to the fact that around 70 percent of the data points are auto populated, calculated, or pulled from defaulted data fields. This reflects a new mindset where the active collection of data by field staff is embraced, and the relative cost in time is freely accepted because of the value the data represents to the conduct of operations. To not collect data would now be seen as a waste, a missed opportunity to understand more about what we are clearing and how we are clearing it.

THE CLEARANCE DATA MODEL

The CDM version tested in Zimbabwe required the collection of up to sixty-six data attributes for each mine found during the course of demining operations. These are split into five main data categories; device data, process data, location data, environment data, and image data.[4] At the point of recording into an electronic form on site (and then uploading the form at the end of the day when at a field camp with internet access), each mine is given a unique identification barcode so that its identity can be confirmed throughout subsequent data processing and analysis.

Device data captures the relevant information for that particular mine. This is not only its model, sub-category, and category, but also key design details such as whether it is a minimum metal mine or not, and whether it contains a cocked striker. The answers for R2M2 mines in Zimbabwe were yes to both of these questions. Other device data included the depth of the item, whether it was tilted and if so, roughly by how many degrees. Also included was whether damage was visually apparent, the mine was assessed as functional, significant weathering was apparent, and the device was assessed as safe to move. In Zimbabwe all R2M2s were no-touch, to be destroyed in situ. Also assessed was whether the device was deemed by the team leader to have been moved away from the pattern during previous years, naturally or by human means. Device data also included detail particular to Zimbabwe, such as whether the mine also had a 100g booster and if so, what color it was.

Process data captures how the mine was found and how it was then destroyed. As the largest data category, it constituted about 27 percent of the data collected. It included the type of land release being employed at the time the mine was found. Typically, this was clearance, but since April 2024, approximately 4 percent of mines have been found during technical survey tasks, albeit the finding of these mines represents the point when such a task will evolve to a clearance operation. One key element of process data was the identity of the deminer and their detector. This allowed for analysis not only of individual productivity but also effectiveness with their main demining tool. The time items were found was also recorded, enabling the identification of patterns such as whether deminers tended to find mines earlier in the day. Other process data included pertinent demolitions data such as the time an item was destroyed relative to when it was found, who conducted the demolition, and what explosive stores were used. In this way the CDM also became an explosive accounting tool.

Environment data also provided the all-important explanatory context for the process and device data. For example, the levels of vegetation were recorded, as was whether watering was required due to the hardness of the ground, and if so, how many liters were required for a deminer on a given day until a mine was found. The weather and temperature were also recorded in order to better understand any changes in deminer productivity indicated by the process data. One piece of environmental data that proved difficult to collect was soil type. More work is required to standardize categorization of soil types, especially given the potential for CDM data to contribute to research on sensor technology including electromagnetic induction detectors.

Image data proved to be an essential component of the CDM. The original model required two images, one at the point of excavation and one at the point of demolition. APOPO added two more, including one of the overall demining lanes and one post demolition. The images were taken using the tablet computers, with metadata alone providing an important date and time verification. The lane image proved an excellent means of verifying the environment data, and sometimes the process data. For example, if it had been reported that the deminer had used 15 liters of water to assist excavation, the lane image, along with the excavation image, might be able to corroborate this. If the deminer had reported many excavations due to false positive signals, the lane image should be able to verify this. The excavation image not only enabled operations managers to check excavation technique by looking at the excavation markings on the trench wall but also details such as mine depth and orientation. The demolition images—showing the use of a 37.5g pentolite charge with a length of detonation cord, and 90 centimeters of safety fuze and a flash detonator—not only confirmed the detonation had taken place, but also indicated the explosive stores used and the quality of the demolition set up, including the charge placement.

The final category was location data and was arguably the most important, at least for land release decision making. A Universal Transverse Mercator zone, northing and easting were recorded for each mine found. The quality of this information increased significantly when Trimble DA2 Differential Global Positioning Systems became available to the program in September 2024. The location data for each mine enables the minefield to be accurately plotted—and expensive clearance decisions, such as fade out distances—to be made on hard evidence. Land release is essentially risk decisions about land made on evidence. Precise location data for each mine is a key enabler for this.

A manual deminer at work in the border minefields in the southeast Zimbabwe. While the vegetation shown here is relatively light, when heavier, a significant amount of the deminer's time was recorded as taken up with the removal of vegetation.

THE FIELD TRIAL

The field trial was conducted from 23 September 2023 to 9 March 2024. During this time data on 877 mines was collected.[5] The aim was to assess if the theoretical CDM really was applicable to live manual demining operations, and more to the point, whether it really was helpful and worth the expenditure of time and effort involved. The trial proved that such levels of data collection, enabled by electronic data forms on handheld tablets, was entirely feasible. Once the hard work of rolling out the system was done, operations mangers soon realized its potential, and how ultimately it would make them far more effective in their roles. While individual lessons concerning specific data attributes were learned, perhaps there were two key lessons from the trial. Firstly, time must be allocated to train staff, especially the all-important team leaders, in data collection and entry. If the trial were repeated a whole week would be allocated to this purpose. Secondly, senior operations staff have to actively review and quality control all data reported from the field. Team leaders have to know that their data will be checked, and this is an important incentive for them to be as accurate as possible in data collection and reporting.

EXAMPLE OF DATA COLLECTED FOR AN INDIVIDUAL MINE

One mine found on 8 March 2024 gives an overview of the data collected. The mine was given Item_Report-240308131025 as an identifier. It was found at 07:29 by deminer Cathrine Mashava of Team 3. The electronic data form was filled out by the team leader Tiko Muchukwani. It was found in an area where vegetation was assessed as relatively light. The weather was sunny and the temperature was 36°C (96.8°F). Cathrine detected the R2M2 mine with a Minelab F3 with a black endcap, serial number 24276. Cathrine had used this specific detector to find twenty-two mines since the trial began (she had used another to find a further nine mines). The ground was hard and Cathrine used 10 liters of water to assist excavation, which is recorded as taking fifteen minutes. Once excavated this mine was found to be at 2cm depth. Cathrine had found mines at an average of 4.74 cm over the course of the trial and had found mines as deep as 10cm. The clearance depth on site was 13cm. The R2M2 mine had a 100g green TNT booster attached. It had tilted in the soil by 90 degrees. (Of the thirty-one mines found by Cathrine during the trial, eighteen were tilted at an average of 47 degrees). The mine, which contained a cocked striker was deemed functional, no touch, and not safe to move. It was subsequently destroyed in situ at 08:12 that morning by the team leader in a single item non-electric demolition, using 0.375g of pentolite, 50cm of detonation cord, 90cm of safety fuze, and a flash detonator

The closed demining lane where APOPO manual deminer Cathrine Mashava detected an R2M2 mine on the morning of 8 March 2024. The mine was given the unique identification code - Item_Report-240308131025.

RISK ASSESSMENTS

One advantage of the expanded operational data collection was that it enabled semi-quantitative risk assessments for demining practice. The use of pertinent risk assessments in mine action is not necessarily as formal or as routine as many might imagine. Where risk assessments are made it is not clear whether these are really based on relevant hard data. There is the potential that part of the probability x severity calculation is at least in part a subjective judgement by the risk assessor, who assigns a number value that then makes calculation seem more scientific than it actually is. Instead, reference to hard data should be standard when assigning likelihood or probability number scores, as well as severity number scores.

The CDM captures data that can feed semi-quantitative risk assessments for demining operations. One risk assessment that was developed during the field trial focused on target excavation of the R2M2. In 2023, there were three excavation accidents recorded in Zimbabwe, in 2022 there were three and in 2024 there were four. The armed R2M2 has a cocked striker fuze and can become more dangerous as it ages since the plastic casing of the mine can loosen, which in turn can

The R2M2 once excavation was complete. The image shows the mine and booster at 2cm depth, tilted 90 degrees; it also shows the sideways excavation technique used, as per the deminer's training.

The R2M2 ready for single item demolition using 37.5g of pentolite. Found at 07:29, the mine was recorded as destroyed by 08:12.

Team leader, Lawrence Mazodze, records on his tablet the details of the 1,735 mine found since April 2024 when operational procedures were updated after a trial from September 2023 until March 2024. The R2M2 mine he is recording was found by deminer Grace Fafteen using a Minelab F3 with a black endcap, serial number 24233. The mine was found at 3cm depth at 08:52 on 6 December 2024.

Team leader, Lawrence Mazodze, documents the successful demolition of the mine using his handheld tablet on 6 December 2024. The APOPO Operations Manager in Zimbabwe, Johannes Nzua, states that "from an operations perspective, our new way of data collection has improved our approach to operations, improving safety, quality, and efficiency. By using accurate and timely information, we can make informed decisions."

lessen the effectiveness of the holding devices such as the lockball. Understandably, the risk assessment was primarily based on accident data. The relative frequency of excavation accidents gave a probability score of four out of five, signifying occurrence was probable (a score of five would be very likely and a score of three would be possible). The severity score was three out of a possible five, indicating a single major injury, consistent with the accidents previously referenced. The CDM provided data pertinent to excavation for an additional score. This included whether watering was required due to the hardness of the ground (13.77 L/item average), the assessed functionality of the mines recorded (98.61 percent assessed as functional), the proportion of mines found tilted (54.6 percent), and whether the mine had design features such as a cocked striker (100 percent) that made it prone to initiation if impacted by an excavation tool. All these data attributes were deemed scoring data.

Other data was included for context, albeit it was not scoring data within the risk assessment calculation. The target excavation risk for R2M2 mines in Zimbabwe was assessed as medium-high, the highest level it could whilst remaining tolerable. All viable risk mitigations were put into place by APOPO, although the residual medium-high assessment is a reminder of the real risks that deminers face in the field. Manual demining of sensitive anti-personnel mines can unfortunately never be deemed safe, although in this case the risks were managed to a level deemed to be As Low As Reasonably Practicable. The onus is on operations managers to make every effort to monitor, assess, and mitigate those risks using the best data practicable, and that requires an expanded collection of relevant operational data. The intent is to develop further risk assessments for specific demining practice. For example, the CDM could provide operational staff with pertinent data that measures the risk of missed mines during clearance.

CORE AND DISCRETIONARY DATA

In order to make the CDM applicable to more contexts than just pattern minefields on the Zimbabwe-Mozambique border, the data attributes were divided into core and discretionary groups. Core data represented thirty-eight attributes that should be collected wherever in the world the CDM is applied. Discretion data tended to be that which was only relevant to Zimbabwe. For example, whether the mine had a booster attached and if so, what was its color? Should a wider application of the CDM be considered within mine action, the core and discretionary designations may be reviewed. However, should a core dataset for all organizations be accepted, it would allow comparison for all mines found by all clearance operators. What is the average depth of anti-personnel blast mines globally? What percentage of mines found contain a cocked striker? What percentage of anti-personnel mines are moved prior to demolition? At present we can't give answers to these questions, on a global, country, or even organizational basis. Adoption of a core data set of the CDM would enable such answers and many more besides.

Figure 1. The device page of the revised APOPO dashboard showing 1,735 mines found since operations were revised in early April 2024 until 6 December 2024, after the field trial of the CDM finished in March 2024. Note that the item report for each mine can be selected with the respective data, including specific image data, visible on the right. This allows forensic quality management by operations managers.

DATA COLLECTION SINCE THE FIELD TRIAL

Following a review after the field trial, APOPO in Zimbabwe has further adapted the CDM and its overall method of collecting data on site. Since early April 2024, a new activity-based approach for individual deminers, compared to traditional end-of-day reporting for a whole demining team, has been adopted. Now process data is gathered in relation to a demining lane, and if a mine is found in that lane, that lane data is immediately related to it. Lane data is gathered immediately whenever a deminer finishes clearance in a lane or a mine is found. APOPO links the different activities and processes associated to a landmine by means of a barcode assigned to the mine. Barcodes are scanned at the end of one activity and the beginning of another activity.

LIMITATIONS ON HOW MUCH DATA CAN PRACTICALLY BE COLLECTED

One of the aims of the field trial, and the subsequent collection of data by APOPO demining teams, was to assess what level of data was practical to collect in the field. Operations managers might wish to know everything and impose a data collection burden to match. However, what data is desirable to know might not be the same as what is practical to gather. The field trial collected sixty-six data attributes, an expansion from the original fifty in the theoretical CDM.[6] The expansion was due to a desire to understand as much of the process of manual demining a pattern minefield throughout the day as possible. This included how much time was spent cumulatively on tasks such as vegetation cutting, marking, detecting, and excavation of false positives. The collection of such data could constitute a continuous time and motion study. However practically and accurately recording such data proved to be a challenge and after the trial, its collection was discontinued. Certain time measuring process data were retained, however. For example, the excavation time for actual mines, averaging 12.77 minutes from April to October 2024, continues to be collected. Other ways of measuring were changed from the trial. For example, vegetation was measured in meters squared cleared that contained vegetation, rather than time taken to cut it.

Some data proved surprisingly difficult to accurately collect. One example was meters squared cleared for each mine found. In theory the deminer could record the meters squared since the last mine they found and then report this in relation to the next mine found. However, deminers could be moved around the site to new lanes and while being productive, they might not be the ones to find the mines that their meters squared of hard work contributed towards accessing. Ultimately it proved to be the case that trying to get an accurate daily run rate on a key performance indicator such as mines per meter squared cleared was better done using a specific form for each demining lane. While the underlying principle that the mine should be the key unit of data against which attributes are recorded remains, it was noted that this approach did have some limitations.

FURTHER DEVELOPMENT

Efforts to refine the CDM for the clearance of minefields will continue, not least to try to find the sweet spot of data that is both practical and desirable to collect. Other aspects that will be improved is the training of team leaders and deminers in data collection, and the development of reference documents that support more accurate data entry. For example, a standard operating procedure was developed that showed examples of different vegetation levels. This could be further enhanced by the equivalent for soil types. An equivalent of the CDM for survey operations, called the Survey Data Model, has also been developed.

ADAPTATION OF THE CDM FOR THE USE OF MINE DETECTION DOGS

The CDM has potential in other respects. For example, there is possibility that a Mine Detection Dog Data Model could be developed that would record each indication a dog makes and relate it not only to whether a mine or other item of explosive ordnance (EO) was found at that location, but also to what else was subsequently found nearby. The received wisdom is that mine detection dogs (MDD) are good at detecting the edge of minefields, and also useful at detecting individual nuisance mines, but are not as effective at detecting individual mines in a pattern minefield. Development of a data model could provide hard data to test these assumptions and an evidence basis on which the use of MDD can be further refined.

The CDM could also be applied to the clearance of cluster strikes. The cost of clearing cluster strikes can be similar to that of minefields. The number of attributes for each unexploded submunition found would likely be much less than for a mine, but a truncated CDM could nevertheless provide insights into the devices found, the process that found and destroyed them, the environment this process was conducted in, and the location of each submunition in relation to the overall cluster strike. (Good operators already record the location of each submunition). The image data for each submunition would also provide a key means of quality management and transparency for donors.

ADAPTATION OF THE CDM TO DEBRIS MANAGEMENT

The CDM can also be adapted to other risk management situations. In several post-conflict early recovery contexts, removal and recycling of debris contaminated with EO provides a particular problem. Such debris represents a distinct challenge since it is practically impossible to search thousands of tons of debris prior to moving it. The varied nature of the rubble, including the presence of reinforcement bar, makes it difficult to use detectors. As with any risk management problem, data might not be a solution, but it is a requirement to manage the risk as effectively as practicable. To that end a version of the

CDM can be adapted for mines and explosive remnants of war found within the debris. In this way both device data about the items found (fuzed or not, arming state, etc.) and process data such as when an item was identified can be relevant. For example, it is assumed that most items of EO are first seen once debris has been moved by a mechanical excavator and spread for subsequent inspection. Others might say that items are identified in the top layer of the debris prior to movement, typically by the plant operator themselves. There is no data to indicate either way. One version of the CDM adapted to the debris problem identified up to thirty data attributes for each item of EO found in this context. The use of the CDM in Zimbabwe would suggest that collecting data for perhaps ten items, possibly more, on a debris site per day would be entirely practicable.

POTENTIAL FOR USE IN ACCIDENT INVESTIGATION

Another area where the CDM could be of significant use to mine action is in accident investigation, particularly in providing hard data for root cause analysis. For example, in a scenario where a missing mine in a demining lane causes an accident to a deminer, if the CDM had been employed on that site, it would be able to show the history of the deminer(s) who had worked in that lane. That would include every mine that deminer and their individual detector had found. Was the deminer involved previously successful in using their detector(s) to find mines at varying depths? The CDM would provide the answer. What was the history of the specific detector in question? (Each mine found in the CDM is related to a detector serial number.) Other accident scenarios may be considered. For example, there is some evidence to suggest that most demining accidents (perhaps 40–50 percent) occur during excavation.[7] The CDM would provide extensive detail about the excavation habits of the individual deminer, comparable to other deminers recorded. What was the average excavation time for the deminer in question in relation to mines of different depth or in relation to ground that required watering? CDM data would provide the answer.

TRANSPARENCY FOR DONORS

The CDM also has significant potential for donors who desire oversight of the operations they fund. In the same way that the image data for a given mine enables new levels of quality management, it also enables oversight by donors funding operations. For the first time donors can see proof of every mine found and destroyed, if necessary, validated by the metadata of the four images recorded for each. It is also a way that demining operators can explain or justify operational difficulties. For example, if mines are found deeper in the soil and therefore require longer excavation times, or the ground is heavily vegetated, again slowing demining progress, the operator has a body of evidence to demonstrate this. It can also be the basis on which popular fundraising may be attempted, with individuals able to see detail of the exact mines they funded to clear, again with a level of transparency and accountability not previously realized in the sector.

ADAPTATION FOR QUALITY MANAGEMENT

As stated, the CDM can be an important aid to quality managers, in that it enables them to have a forensic understanding of the demining operations that they are monitoring. However, an adaptation of the CDM for quality management could also be beneficial. This would involve not only the conscientious recording of critical or noncritical nonconformities, but also more data on the actual process of a site visit. Any operations manager should know how much time each of their deminers have been directly monitored and when they were last subject to internal or external quality assurance. Data collected in such a Quality Management Data Model (QMDM) could also be related to the respective CDM data. For example, a QA officer witnesses a rapid excavation of a signal. They can compare the time taken to the median times taken for mines at a similar depth on similar sites in similar conditions. The principle of expending more time to collect relevant data also applies to quality management and can enable us to really know a process we might have assumed we fully understood in the past.

COMMON OPERATIONAL DATA SETS

One lesson that continues to be apparent throughout the trial and the subsequent operational development of the CDM, is the need to improve the Common Operational Datasets (COD). The CDM is split into core and discretionary data categories. As stated previously, the core data categories can be applied to contamination globally, whereas the discretionary data is applicable to the Zimbabwe context only. The core dataset can act as a COD although more is required above the CDM. For example, mine action does not have a satisfactory taxonomy for EO. The loose system currently outlined in IMAS 05.10 gives three levels of categorization for EO: category, sub-category, and model.[8] The system has no requirement for standard entry of model names and provides no guidance on this. The sub-category also only provides limited information—for example, the different types of anti-personnel mines, such as blast, directional, omni-directional, and bounding fragmentation are not included. The list of ordnance sub-categories is also limited. For example, fuzes are not included but will be found in the field and should be part of a future taxonomy. How can a fuze be recorded using the current system? At present they can't. Some existing sub-categories such as cluster munitions require changing to explosive submunitions in order to align to Article 2 of the Convention on Cluster Munitions. Development and then constant updating of a taxonomy by technical staff with expertise in EO and operational experience would greatly benefit the mine action sector. A further developed taxonomy for victim operated improvised explosive devices would also be beneficial, albeit would require more levels in order to describe satisfactorily. The value of CODs is becoming increasingly recognized elsewhere in the humanitarian sector.[9] Mine action has further work to do in this direction in order to describe devices satisfactorily.

OPERATIONAL DATA AND TRAINING OF FIELD STAFF

One key lesson from using the CDM in Zimbabwe was the importance of effectively integrating data collection, analysis, and use in training not only of conventional EOD and humanitarian IEDD operators but also for all field disciplines such as demining and Battle Area Clearance. This is especially true for those in any sort of supervisory role, such as a section commander or a team leader. All should understand clearly why they are collecting operational data and how it helps them. There was some progress towards this with the recent Conventional EOD and Humanitarian IEDD competencies,[10] however more is required. Accurate data collection should be taught and practiced during EOD, demining, and searcher courses. The feedback from data analysis to field practice should be demonstrated and practiced by students. For example, something as simple as the clearance depth on site can be justified to clearance staff by a simple review of the depths at which all mines are found.

CONCLUSION

The field trial and ongoing use of the CDM in demining pattern minefields in Zimbabwe demonstrate the practicality of collecting significantly more relevant operational data. Team leaders now devote nearly 20 percent of their time to this data collection. It also showed it is entirely feasible to make the mine, not the area, the unit of data about which relevant attributes are recorded. Furthermore, the operational data approach, with the data required selected by operations staff for operations staff, has enabled the development of not only semi-quantitative risk assessments, fed with data daily, but also significantly enhanced quality management and overall operations management. The difference in terms of a real understanding of the operations might be likened to turning on the lights. Operational data has a real value, and the resources and time spent in its collection represent money well spent. If the value of operational data was realized throughout mine action, the insights provided could be exceptional.

See endnotes next page

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