The Journal of Conventional Weapons Destruction

Volume 25
Issue 1 *The Journal of Conventional Weapons Destruction Issue 25.1*

Article 7

September 2021

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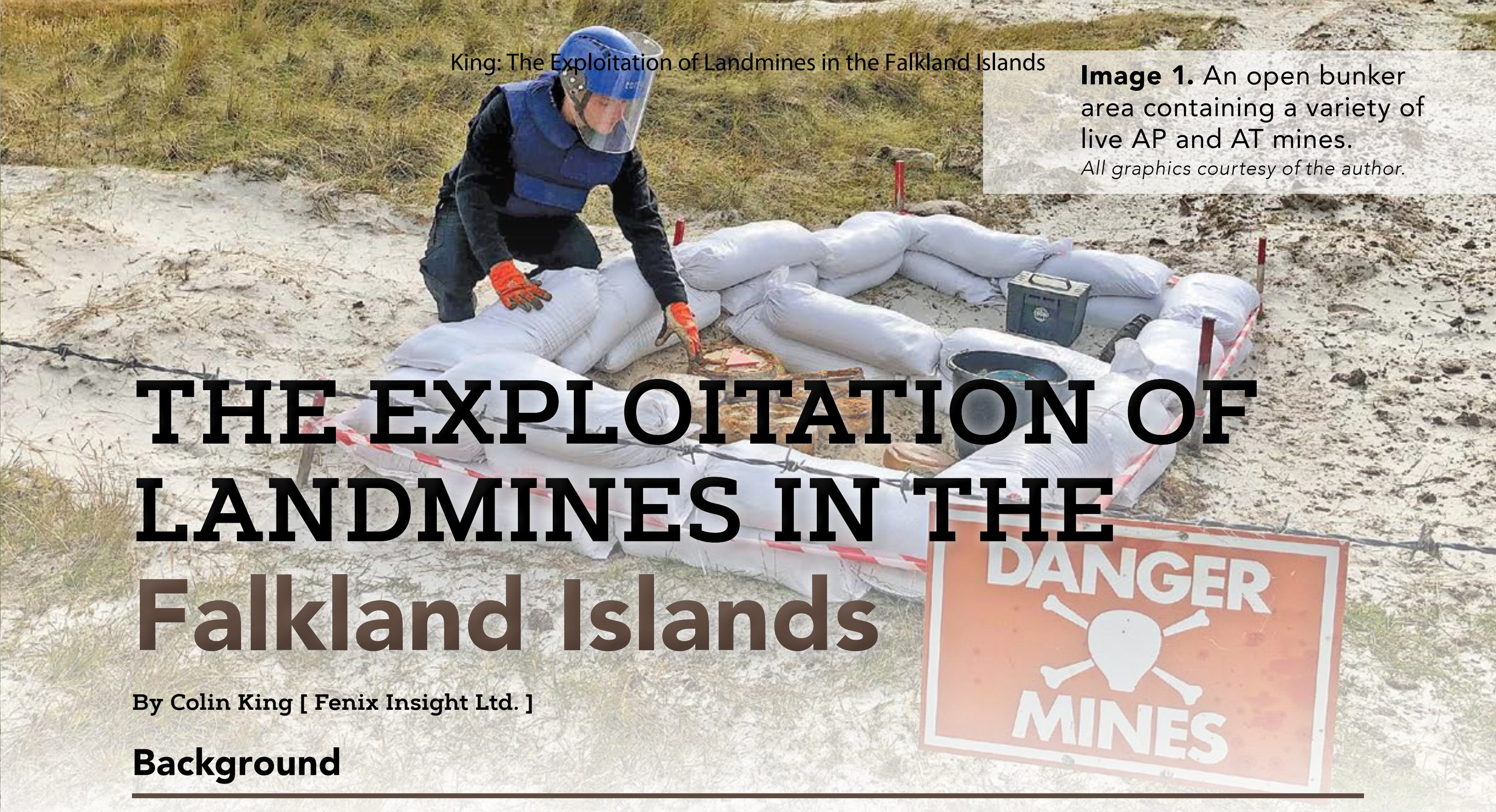

Image 1. An open bunker area containing a variety of live AP and AT mines.
All graphics courtesy of the author.

THE EXPLOITATION OF LANDMINES IN THE Falkland Islands

By Colin King [Fenix Insight Ltd.]

Background

Throughout the eleven-year mine clearance program in the Falkland Islands, the *exploitation* (disassembly, detailed analysis, and testing) of live mines was a regular feature. In addition to assessing the condition of the mines in order to optimize the safety and efficiency of the clearance process, there was intense interest in the subject of long-term residual risk.

The rigorous demining program was highly successful, and the Falkland Islands have now been declared clear. However, a mine recently washed up on the shore near the Capital, Stanley, and it's possible that others will do so over the next few years. It is also clear that findings from exploitation work in the Falkland Islands can make a significant contribution to the understanding of residual risk in other mine-affected regions.

During the final phases of the program, the discovery of Israeli No. 4 anti-personnel (AP) mines triggered a request from SafeLane Global, the land release contractor (LRC) and Demining Programme Office (DPO) for a technical assessment of their condition. Initially, this took the form of a remote desktop study based on images of recovered mines, which were compared to inert examples and technical data held by Fenix Insight Ltd. The aim was to consider the likely effects of ageing and their implications for the handling and disposal of the mines.

Soon after, the LRC also began to encounter Argentinian M1 and Israeli No. 6 anti-tank (AT) mines, as well as Argentinian FMK-1 AP mines. Once again, as the clearance program entered its final phase, questions of residual risk, handling, and disposal were raised, and an exploitation visit was planned in order to assess

- the general condition of the mines
- the functionality of fuzing mechanisms
- the viability of energetic materials
- the implications of changes for risk

The work was conducted in March 2019 by Colin King, Technical Director of Fenix Insight Ltd, assisted by Max Grace, Fenix Operations Assistant, and supported by Guy Marot, who ran the DPO.

Risk Assessment

Risk assessment is always a fundamental part of the planning process and follows a well-established Fenix protocol. It considers the likelihood and potential consequence of each hazard in order to allocate a combined risk score, often involving multiple team members in order to capture technical and procedural considerations across a range of scenarios. Where appropriate, controls are then applied to manage the risk to make it *as low as reasonably practicable* (ALARP).

Previous deployments have illustrated the value of this process when, for example, the *worst-case scenario* of a firing pin remaining lodged in a live detonator was found to have occurred in several mines.

Logistics

A temporary ammunition processing building (APB) was set up at Yorke Bay, outside Stanley, in a shipping container with a workbench and vice, a generator, and lighting. A specialist tool kit was brought from the United Kingdom to supplement the tools and equipment retained from previous exploitation phases; this included jigs built by Fenix for the disassembly of machine-assembled mines. The only power tools were a large commercial band saw and a cordless drill.


Image 2. The APB was established in a shipping container, placed among the sand dunes of Yorke Bay, near the capital, Stanley.

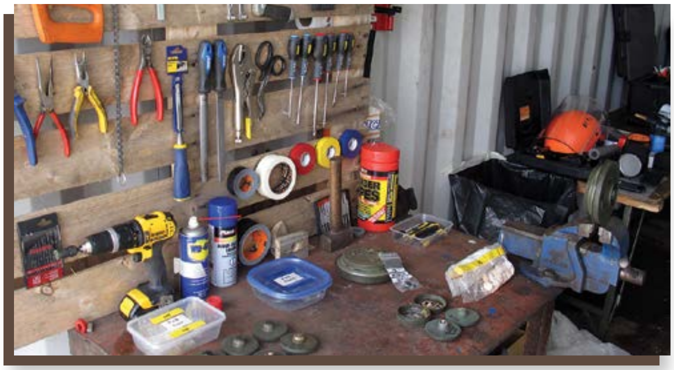
Image 3. A simple work station was set up, with specialist tools and disassembly jigs brought from the United Kingdom.

Mines, recovered by the LRC during clearance operations were retained in open sandbag bunkers within the minefield fences and therefore well away from public access. Their continued exposure to the weather meant that mines were not subjected to artificially dry conditions that might have altered their state. The M1, No. 6, and No. 4 mines had been dug up in sand and processed through the sifting system; they had therefore been subjected to significant disturbance, possibly including substantial pressure and vibration.

Methodology

The workflow followed a standard Fenix process map for exploitation activity. For each mine type, this involved full disassembly and examination of critical components. In order to assess the capability of a mine to operate as designed, the three main areas of interest were:

- the integrity of the casing
- the functionality of the fuzing mechanism
- the viability of the explosive compositions

It is well established that secondary high explosives such as TNT remain capable of detonation for many years; this is illustrated by the continuing viability of ammunition from World War I after more than a century. Since the main charge is almost always found intact, the key element in the explosive train is the detonator. No matter what the condition of the body, the fuze mechanism, or the main charge, a mine is incapable of functioning as designed unless the detonator is serviceable. The testing of detonators was therefore critical to the real-world evaluation of the risk posed by these mines during the final stages of clearance, and for the prediction of long-term residual risk in other regions.

A simple rig was improvised to allow a spring-loaded striker to be released from behind the cover of the shipping container, while the test was captured on video. The initiation mechanism was improvised from a recovered No. 4 mine fuze, with the components restored to full functionality and checked before each operation.

Findings

Throughout the studies on the ageing of mines, the ingress of water has been established as the greatest single influence on the degradation of internal components. This in turn means that the integrity of the casing (its ability to remain waterproof) is important. The mines that were present in the Falkland Islands included significantly different designs and materials. Some of the plastic casings proved extremely robust, yet others had degraded badly. Some steel casings had thick external rust but still retained their integrity beneath, while a well-sealed fuze body effectively acts as a separate casing within a casing.

The vulnerability of internal components also varies substantially. Some fuzing mechanisms incorporate virtually impervious plastics and stainless steels, while others contain components made from rust-prone iron and mild steel. Explosive initiators also vary in design and vulnerability, some being seriously degraded by small amounts of salt water.

Previous phases of exploitation focused mainly on the plastic-cased mines encountered inland (SB-33, SB-81, P4B, and C3B), with findings suggesting that the entire population of mines in the Falkland Islands might be nearing the end of its operational life. However, the examination of four additional mine types (FMK-1, M1, No. 4, and No. 6) from coastal areas casts doubt on that conclusion, with all of these found to pose a continuing risk during the final stages of clearance. Additionally, unlike those seen previously, the SB-33 mines examined here showed no indication that they were nearing the ends of their operational lives.

A constant worry in old munitions is the interaction of primary explosives with some metals to form highly sensitive compounds. Fortunately, most mines of the types that were present in the Falkland Islands use aluminum or plastic detonator capsules, and there is no evidence that this is a problem.

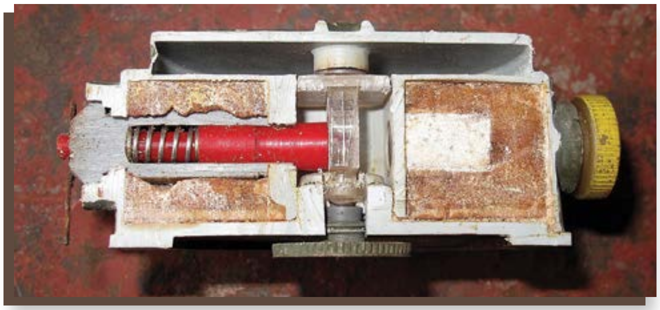

Image 4. A section through the Argentinian FMK-1 shows that the casing, charge, and fuzing components are in excellent condition.

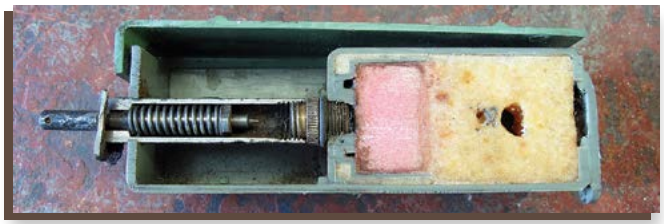

Image 5. A section through the Israeli No. 4 mine. The fuze striker is partially seized, but the explosive train is still functional.

Image 6. The heavily rusted casing of the Israeli No. 6 AT mine.

The only consistent theme is the condition of the secondary explosive where, as expected, all of the main charges and boosters remained functional. In general, the risk from this bulk energetic material is only significant if an operational initiation train is also present. It's *not* that this secondary explosive is *safe*, since it clearly retains the potential to cause accidents if mistreated, but detonation requires a level of energy input well beyond those involved in everyday events, such as bonfires or digging.

Quite often with aged ammunition, what you see is what you get; if it looks badly degraded then generally it is. But nothing better illustrates the need for exploitation, or the potential for counter-intuitive findings, than the Italian SB-81 and Argentinian M1 AT mines. Most of the SB-81 mines looked almost factory-fresh, while the M1 mines were heavily rusted and sometimes barely recognizable. However, the SB-81 striker springs were heavily corroded, and the detonators' stab-receptors were non-functional, rendering the mines incapable of operating as designed.

Image 7. A section through the No. 6 mine reveals that, much like the No. 4, the fuze is partially seized but the explosive train remains functional.

Image 8. A disassembled Italian SB-33 mine, showing most components in good condition.

Image 9. Most of the M1 mines were heavily rusted.

Meanwhile, underneath layers of rust, the M1 casings were largely intact, firmly encapsulating robust TNT charges. The M1 fuze has a heavy brass body, offering complete protection to the mechanical and energetic components within. Testing the detonator established beyond doubt that these mines were fully capable of functioning.

Image 10. Detonators from the SB-33 mines appeared virtually as-new, and were fully functional.

Image 12. The SB-81 striker springs had rusted away.

Image 11. Externally, most SB-81 mines appeared to be in excellent condition.

Image 13. The stab-receptors of the SB-81 detonators were no longer functional.

Key Conclusions on Residual Risk

The variety of designs and materials means that each mine component has its own level of vulnerability, combining to incline the entire mine towards resilience or susceptibility. The failure of one key component will usually prevent the mine from functioning as designed; however, the simultaneous failure of two key features adds a significant level of confidence, particularly if one failure relates to the fuzing mechanism, and the other is within the explosive train. This is the case for the SB-81 and C3B AT mines, which are the only two types that have washed ashore. Should this occur again, there is a high degree of confidence that these mines would not be operational.

The nature of the environmental influences is also important, accepting that the *micro-climate* in which mines are located may vary significantly, even if they are close together. For example, one mine may be partially buried in very wet ground, while another nearby may rest on the surface of well-drained soil but be exposed to sunlight.

The presence of sand and salt water added further ageing influences to those present inland, with sand having abrasive effects and blocking mechanisms, and salt water being more corrosive. This means that mines in coastal areas should deteriorate faster than similar types located inland, but this was not always found to be the case. P4B and SB-81 mines were definitely in worse condition than those recovered inland, yet the Italian SB-33 AP mines were better, possibly reflecting tighter insertion of the detonator plug to seal the mines.

Table 1 summarizes the findings and conclusions from the exploitation of mines recovered in and around coastal areas in the Falkland Islands as the clearance program neared conclusion. The findings might apply to these mine types in similar environments, if they were to be encountered in other regions.

Quite often with aged ammunition, what you see is what you get; if it looks badly degraded then generally it is.

Designation	Technical findings	Conclusion
FMK-1	Resilient casing resulting in the fuzing mechanism and explosive train being well preserved.	These mines could have remained functional for many years.
"M1"	Fuzing mechanism and explosive train remain well preserved, despite heavily degraded external appearance.	Some mines were still fully functional.
SB-33	Mines in good condition, with fuzing mechanism and explosive train (particularly detonators) very well preserved.	These mines could have remained functional for many years.
No. 4	Fuzing mechanisms complete but seized. Explosive trains intact, with some detonators found to be functional.	Incapable of operating as designed. However, the presence of complete mechanical and explosive systems carried the risk of unintended initiation mechanisms.
No. 6	Fuzing mechanisms complete but seized. Explosive trains intact, with the possibility that some detonators may remain functional.	Potentially capable of operation if subjected to substantial pressure or shock—could have been sensitized during extraction.
P4B	Loss of structural integrity, allowing ingress of water. Fuzing mechanisms incomplete due to rusting of the striker spring. Detonators unlikely to function.	Two or more points of failure mean that these mines were unlikely to operate.
SB-81	Fuzing mechanisms incomplete due to rusting of the striker spring. Detonators unlikely to function.	Two points of failure mean that these mines were unlikely to operate.

Table 1.

Recommendations

The results of the exploitation work were briefed to the demining team leaders and management, and a number of recommendations were made. In particular, it was recommended that the LRC consider the potential risk of initiation during the excavation or sifting process with the M1 and No. 6 AT mines. They were also warned of the possibility of sensitization during these processes, which could substantially lower the operating threshold, and to therefore apply appropriate additional control measures. As a result of these findings, appropriate adjustments to operating procedures were implemented.

Following the end of the clearance program, it was also recommended that awareness messages and education on residual risks should include images of the mines as they now appear: aged, rather than as-new.

Conclusion

Inevitably, mine populations will continue to degrade to the point where all eventually become safe. However, where previous studies indicated that this state might be achieved relatively soon, findings from this recent work suggest that some mine types can remain functional for many years, even in the harshest environments.

This conclusion, along with some of the surprising and counter-intuitive technical findings, reinforces the need for exploitation work to provide a sound foundation for evidence-based decision-making. The global issue of residual risk from landmines is simply too important to be based on assumption or myth.

BIOGRAPHY

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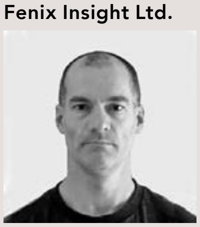

Colin King served as a bomb disposal officer in the British Army, with operational tours including the Falkland Islands, Persian Gulf, Bosnia and Herzegovina, and Kosovo. He instructed at the British EOD School and spent many years in military intelligence, also leading the first British team to train Afghan deminers before his final tour with the Gurkhas.

He is now the technical director of Fenix Insight Ltd., with tasks including the disassembly and analysis of live munitions in conflict zones throughout the world. King also writes the leading technical reference work on EOD for Janes Information Group.