1. Executive Summary

Most of the mines that currently threaten populations were manufactured more than 50 years ago and many have been in the ground for 30 years or more. Despite the inevitable and obvious deterioration, there has been very little research into the effects of aging on landmines.

In 2008, James Madison University (JMU), the Center for International Stabilization and Recovery (CISR), and C King Associates Ltd (CKA) began a study designed to understand the aging process and the range of implications for the various components of mine action. The two-and-a-half year study was funded by grants from the US Department of State, Bureau of Political-Military Affairs/Office of Weapons Removal and Abatement.

Methodology

The study involved the following four key elements:

1. **Field work.** The study team worked with demining partner organizations in Cambodia and Jordan, where a range of live mines were located, recovered, disassembled and examined in detail. Geo-referenced images were taken at every stage and soil samples were recovered from around each mine. Further data came from the Falkland Islands, where CKA was conducting similar work. Additional anecdotal information and images were gathered from several other mine-affected regions in which CKA had worked.

2. **Scientific analysis.** The Science departments at JMU conducted analysis of mine components in order to classify the materials and examine patterns of degradation. The soil samples were analyzed to identify relevant characteristics and look for correlations with the condition of mines.

3. **Literature review.** A literature review was undertaken to establish what work had already been conducted in this area, although little was found. Once the component materials had been identified, existing research supported observed common degradation effects.

4. **Predictive modeling.** Theoretical tools were developed in order to model the observed effects. Although basic at this stage, these have the potential to evolve into sophisticated models with which to predict the degradation process across a wide variety of mines.

Key findings

The study identified a broad range of significant findings, which include the following:
• Landmine aging is happening now; many mines already show a high degree of degradation.

• Aging has substantially altered the appearance of many mines. The pictures and models used for mine-risk education and deminer training are often inaccurate and misleading.

• Most mines are becoming non-functional, although the rate at which this occurs is dependent on a range of factors. Although some mines may become more dangerous as they deteriorate, this is rare.

• There are many ‘failure mechanisms,’ but most occur as vulnerable materials degrade.

• Penetration of the outer casing, exposing internal components to the environment, substantially accelerates the rate of deterioration and reduces the lifespan of the mine.

• A ‘vulnerability index’ (VI) for a mine can be determined from key component materials. This modeling allows the prediction of aging effects and extrapolation to similar mines.

• The likely lifespans of different mine types in a country can be made; however, far more data is required from the field to allow statisticians to develop reliable projections.

Conclusions

Analysis into the effects of aging on landmines is long overdue, but far more data is needed. The study has revealed implications for virtually every component of mine action; it is simply no longer acceptable to treat mines as though they were new.

At the strategic planning level, findings should contribute to the prioritization of tasks and allocation of resources, while policy-makers will need to consider the questions raised about mine lifespans and definitions. At the field level the findings have clear implications for the selection of equipment and techniques. MRE materials should reflect the appearance of mines as they are now, not as they were when new. Changing characteristics should be considered during research and development of new equipment.

It is clear that further work is needed to understand the aging process in more depth, and that more information is required in order to refine the VI and lifespan models. The participation of mine action organizations would contribute greatly to the gathering of data, much of which is currently lost. In return, a better understanding of the effects of
aging on mines has considerable potential to enhance mine action by making it safer and more cost-effective.