Toward the accreditation of LOCOSTRAv2: results of pre-tests

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Abstract

The paper presents results from a long work aimed at filling an important gap in the standardized protocols for testing and evaluating demining machines. While, a CEN workshop agreement (CWA) on testing and evaluation of demining machines designed to detonate hazards exists, no such a similar agreement is in place for testing and evaluating demining machines for technical survey and area preparation. The work introduced here aims at filling this gap, explicitly stated in the CWA currently in place: "It is recognised that this CWA [CWA 15044:2009] concentrates on the testing of machines employed to clear mines, and there is a need to expand future work to address a number of issues". Preliminary results obtained applying the proposed system to the pre-test of LOCOSTRAv2 machine are also presented.

Existing standards and needs

The current CWA on T&E of demining machines (CWA 15044:2009) is explicitly targeting machines designed to detonate or destroying landmines, in particular flails and tillers. Their evaluation is based on their ability to initiate, neutralise or damage mines.

IMAS 09.50 (August 2012) defines demining machines as "all machines that are designed to be used in hazardous areas". Demining machines are then divided into three categories: "machines designed to detonate hazards; ground preparing machines; and machines designed to detect hazards". At this time, there is no CWA (or other standard) defining how to test and evaluate ground preparing machines or machines designed to detect hazards.

IMAS 09.50 (August 2012) states that while ground preparing machines are aimed at "improving the efficiency of demining operations by reducing or removing obstacles", machines designed to detect hazards "may do it physically, as with sifting machines and rollers, or by carrying a detection technology such as metal detector arrays or vapour sampling devices". There are guidelines appropriate to the test and evaluation of some detection devices in CWA 14747:2003 Test and Evaluation of Metal Detectors. Machines carrying ground roller systems fit into the definition of machines designed to detonate or destroy hazards.

Because no standard means of testing and evaluating them exists, it is appropriate to include both sifting machines and ground preparing machines in the broader category of machines for Area Preparation. In both cases, when machines are used in a land release process, they need a manual follow-up. This usually is done in-situ but can be conducted remotely when the machine moves the processed soil and the sifted material is examined in another location.

Currently, machines designed to detonate or destroy mines such as flails and tillers are frequently used in Technical Survey (TS) [Cepolina E.E., 2013] operations because they are the only machines available. Their use can be inappropriate because the objective of TS is not to destroy mines, but to collect information about the threat. According to IMAS 08.20 (March 2013) among the assessment of the performances of different assets in the survey role "the extent to which the asset will preserve information associated with hazard items and other aspects of the surrounding environment" should be taken into account.

To comply with IMAS 08.20, when evaluating a machine's suitability for use in TS, it is not appropriate for the assessment to be based on its ability to initiate or damage mines as though that were an essential feature.

During TS, other assets are often used after the mechanical assets and the procedures conducted subsequently should be informed by the output of the mechanical assets. For example, the evaluation of machines for TS should include assessment of characteristics that may affect the selection or performance of metal detectors, mine detection dogs or any other follow-up asset, including other implements attached to a machine.

When assessing a machine's suitably for use in TS tasks, its ability to withstand the detonation of explosive devices should be assessed with reference to the manufacturer's claims for the machine's capabilities. For example, if the manufacturer claims that the machine can withstand the blast from an AP mine under its wheels or tracks, an explosive test should be conducted to verify that claim.

Guidelines that take into account all useful outputs of machines for TS and the effects on assets used after them when testing their performance would be beneficial to the mine action community.

The fact that there is no agreement on how to test and evaluate machines for TS and Area Preparation has two main drawbacks: it makes their adoption difficult for any organization and so makes machines designed to detonate or destroy mines the most obvious choice in every occasion, even when the output desired is not the one of detonating or destroying mines. This leads to a misuse of machines that may lead to unnecessary waste of resources and a reduction in safety for those working after the machine.

By providing a framework for defining the role of varied machines in TS and Area Preparation and by agreeing the performance expected from these machines, the path towards a widespread and informed adoption of new, cost-efficient, TS technologies can be opened. Machines have the potential to be used for Area Preparation and TS on a much wider scale because their cost can be reasonably predicted to be much lower than the cost of those demining machines designed to detonate or destroy mines. The role of a machine for TS and Area Preparation is limited to the investigation of Suspected Hazardous Areas (SHA) so they do not have to withstand multiple detonations. When a detonation occurs, the contaminated area has been located and the machine can be either withdrawn or moved to another area.

The test and evaluation shall provide users and donors with useful and reliable data. This will permit users, donors, machine designers and others to assess the effectiveness and efficiency of particular equipment and so improve operational effectiveness and safety in HMA operations.

New test and evaluation protocol

The proposed new test and evaluation protocol follows the structure of the current CWA protocol and is divided in a step by step approach. In fact, it foresees a pre-test assessment, a performance test, a survivability test and an acceptance test. The difference between the current CWA and the new protocol lays in the fact that the new test is thought to take place in contaminated countries, partly in cleared areas nearby SHA and partly in SHA.

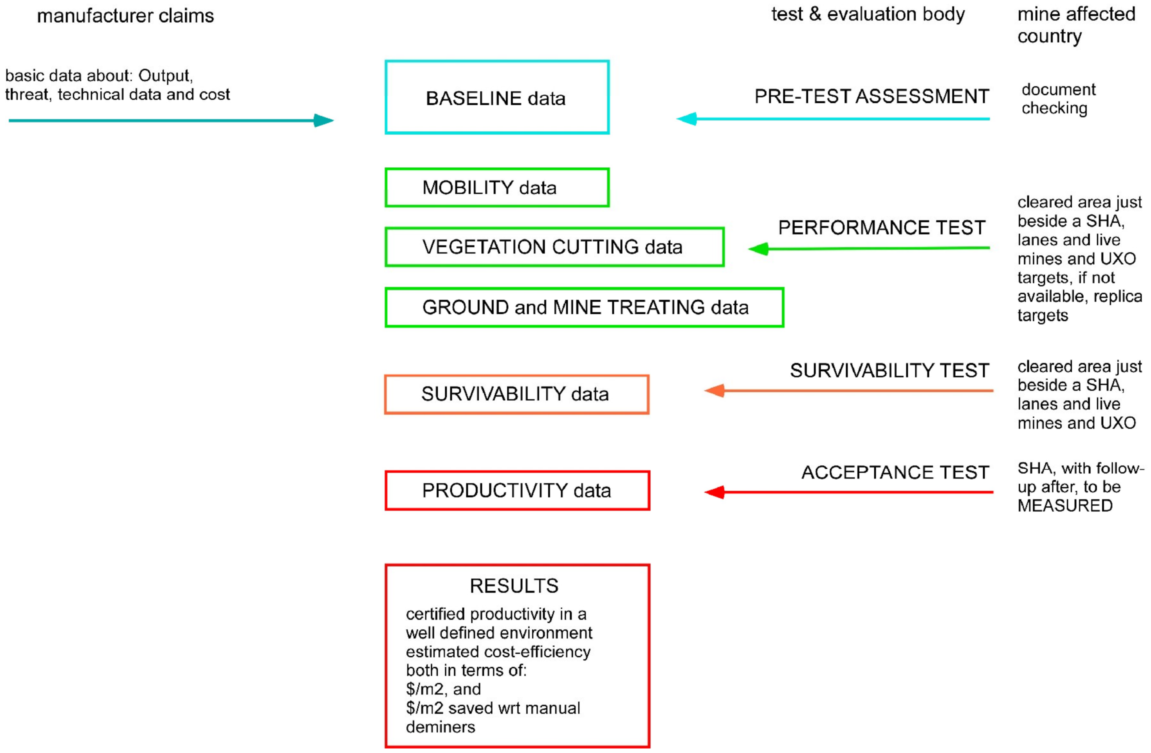

Fig.1. Scheme of the proposed new test and evaluation protocol for demining machines for TS and area preparation

The main idea is to assess the performance of machines in realistic conditions and then to define the characteristics of the particular realistic environment in which the test took place using a limited number of meaningful parameters easy to measure in the field by any non specialised team.

For this purpose, it seems particularly appropriate to use a parameter developed by the WES US military to define the soil compactness with a single number, the cone index value.

Fig.2. Cone penetrometer

The cone index is a light, relatively cheap and easy to use tool, whose reading brings together three soil characteristics, the soil cohesion, the angle of internal friction and the angle of friction between metal and soil. Although the influence of each one of these three parameters cannot be isolated and therefore the theoretical maximum drawbar pull of a machine cannot be calculated using theory (cohesion and angle of internal friction would need to be known), the cone index value allows to estimate the ability of a vehicle to move and to carry implements on a certain type of ground. Thanks to a large literature on the empirical correlations between vehicle performance and cone index values, many different equations have been developed and can be used to predict soil trafficability.

Thanks to its simplicity the cone index value is largely used also in agriculture to predict the drawbar pull of tractors on different soils and match them with the right implements.

Therefore, by characterizing the ground in which tests take place and associating measured results to a particular type of soil, it would be possible to create a library of reliable data on the realistic performance of a certain machine in different environments. If this library would be made public, it would help program managers to use the safest, most cost-efficient and the most appropriate machine for their needs.

Pre-test of LOCOSTRAv2

In parallel to the work on a proposal for a new CWA, the pre-tests of LOCOSTRAv2, aimed at pre-verifying the performance of LOCOSTRAv2 before the official accreditation in a mine affected country, are under going.

Pre-tests on LOCOSTRAv2 therefore follow the steps proposed for the new CWA: pre-test assessment, performance, survivability and acceptance tests. Because the pre-test are taking place in Italy, not all steps are taken. For the moment, the research team is focusing on pre-test assessment and performance test.

The pre-test assessment scheme developed for LOCOSTRAv2 and proposed for the new CWA consists of the verification of baseline data provided by the manufacturer. The manufacturer is asked to fill in a form including data about the following topics:

- Output expected from the machine in terms of vegetation processing, ground processing and mine processing, removal of obstacles, geometry and mass properties allowing to estimate the soil trafficability for different environments characterized by different values of cone index at chosen wheel slip and types of vegetation.
- A section dedicated to technical data provided by the manufacturer; to be as objective as possible, these data should be supported by relevant documentation, such as data sheet of engine used in the machine.

  Some of the technical data presented here are underlined, because they are measured. Some of these can be verified by the entity in charge of the test and evaluation.
- The last section of data refers to cost-efficiency data. Here data about the ordinary maintenance of each separate component of the machine (such as engine, implement) should be reported together with an estimation of the lifetime of the machine and tools and the cost of transportation and custom. The latter have to refer to the cost incurred to bring the machine to the test site in the mine affected country and have to be supported by invoices.

The data contained in the baseline data form feed two separate excel sheets called soil trafficability model and cost-efficiency model.

These two models allow predicting the drawbar pull of the machine in different types of soils, characterized by different cone index values, the first, and predicting the effective cost per metre square of the machine, the second. The latter needs to be fed also with results from performance tests to assure accurate estimation of fuel consumption and speed of work are taken into account.

Thus, a comprehensive system has been developed that allows the user to get a quick and meaningful picture of the machine.

Figure 3 shows preliminary results of the soil trafficability model fed by geometry and mass properties from the baseline data form for LOCOSTRAv2. The soil trafficability model developed compares results obtained using three different empirical equations, cited by [Macmillan, 2002], developed by [Wismer and Luth, 1973] and Brixton [ASAE, 2006] respectively.

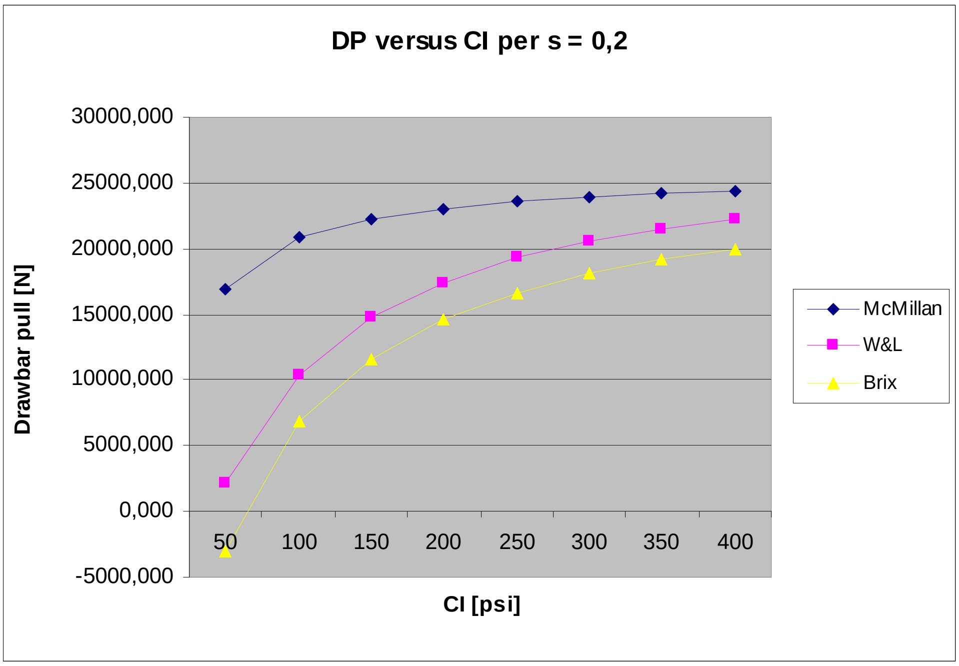

Fig.3. Drawbar Pull (DP) versus cone index values of different types of soils at wheel slip (s) equal to 2%, value typically used in military soil trafficability analyses.

While a different form has been developed for LOCOSTRAv2 equipped with every implement, a single trafficability model exists, containing in separate sheets also the predicted draught force required for each implement according to the depth of work and the type of soil.

The performance test scheme developed for LOCOSTRAv2 and proposed for the new CWA foresees the measurement of performance results of the machine. The first category of performance values to measure regards the mobility of the machine. Than the performance in terms of fuel consumption and productivity, with respect to the output stated in the baseline data form, is measured in different types of soils and vegetation.

Figure 4, 5 and 6 show the preliminary measurements of the minimum radius of curvature of the machine equipped with a trailer to carry a ripper implement, the preliminary measurements of capacity on vegetation cutting, beside a table presenting cone index values measured in four different points at the test site.

Fig.4. Mobility measurements in performance tests: measurement of minimum radius of curvature

Fig.5. Performance tests: measurement of capacity in vegetation cutting.

Depth [mm]	Cone Index (CI) at point n.1 [psi]	Cone Index (CI) at point n.2 [psi]	Cone Index (CI) at point n.3 [psi]	Cone Index (CI) at point n.4 [psi]
76	150	170	50	100
152	180	250	100	180
228	200	300	180	180
304	210	250	200	200
380	190	200	210	100

Fig.6. Cone index values measured at test site.

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