In-field tests of LOCOSTRA in Jordan

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Abstract

The paper summarizes results obtained during the in-field test of LOCOSTRA machine that took place in Jordan during February-March 2011 with the very important support of Norwegian People's Aid Jordan, the National Committee for Demining and Rehabilitation, the Geneva International Centre for Humanitarian Demining and the University of Jordan. LOCOSTRA is the output of an 18 months project co-funded by the Italian Ministry of Economic Development and the Italian Institute for Foreign Trade and coordinated by the University of Genova. The test was very successful and proved the concept of LOCOSTRA tractor as a reliable, easy to use, versatile verification asset to be used in technical survey. LOCOSTRA could speed up technical survey operations consistently thanks to its low cost (50.000€), its local worldwide sustainability and its simplicity. Being a modified tractor, LOCOSTRA can be used in agricultural activities when demining is over.
LOCOSTRA is produced and sold by Pierre Trattori with the support of Snail Aid – Technology for Development.

1. Introduction

LOCOSTRA as verification asset can be equipped with many different tools:

- a mulcher that allows vegetation to be cut and a visual inspection to be done either by a person on a small tower, by a camera on a balloon, or a video camera on board, or
- with a agricultural derived tool for removing/destroying landmines, or
- with an array of metal detector or a large loop detector to check for the presence of metallic parts of buried mines.

According to the tool with which the tractor is equipped LOCOSTRA machine can be classified as ground preparing machine, ground processing machine or mine protected vehicle (used as a platform for a detection system in a SHA). LOCOSTRA is an intrusive, remotely operated machine. Being the overall weight of the tractor and the blast resistant wheels approximately 3000 kg, the machine can be classified as light.
LOCOSTRA is better described in [1] and in the project website, but its main characteristics are reported here for reference. LOCOSTRA is based on a 77hp, 4WD small tractor, 3.5m long, 1.45m wide and 2.3m high. The only components added to the original tractor are:

- Innovative blast resistant wheels, designed to resist several explosions (at least 5) while protecting the tractor from damages caused by the explosions. Wheels are essentially built around a COTS solid rubber wheel embedded in an outer steel structure providing ventilation and protection.
- Remote control system, designed to allow driving the tractor from the safe distance of 100m. It's of industrial type and with a very simple human machine interface. Only essential commands are actuated remotely by electro-hydraulic valves mounted in parallel to hydraulic valves that were on board in the original tractor. Therefore LOCOSTRA can be driven both on board with traditional commands and remotely by the transmitter.
- Armouring; simple metal sheets 3mm thick are mounted to protect delicate parts.

LOCOSTRA reached Jordan equipped with agricultural pneumatic wheels, pulling an agricultural trailer containing tools needed for the test. This configuration was used to drive LOCOSTRA to the test sites and for short distance movements. Among the tools contained in the trailer were the blast resistant wheels, a small crane plus hoist to be mounted at the back of the tractor for loading and unloading the trailer, an UPEX large loop detector kindly provided by Ebinger, but unfortunately not used for tests, and a mulcher

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kindly provided by FAE – Advanced Shredding Technologies, UML/ST 150 type. The University of Jordan kindly provided the ground processing tool that was used during the test: a potato digger produced by Nardi / F.lli Spedo, model type CP-BD-150.

Fig.1. LOCOSTRA and trailer, LOCOSTRA and ground processing tool (potato digger), LOCOSTRA and mulcher.

2. Test conditions

The test took place in two different locations: in the safe area in front of the minefield Sabha12 along the boarder with Syria, near to Jabir village (later on referred to as Jabir test site) and in the suspected hazardous area (SHA) near to the border with Israel near to Karama village in the Jordan Valley (later on referred to as Karama test site). Jabir test site had no vegetation and class I soil (according to the CWA 15044:2009); Karama test site had vegetation and class I soil.

The test protocol followed as much as possible the CWA15044:2009 and took place in three subsequent phases: Performance test, Survivability Test and Acceptance test. Depending on the vegetation and on the landmines used, LOCOSTRA was equipped with the ground processing tool (GPT), i.e. the potato digger, or the vegetation cutting tool, i.e. the mulcher, or with no tools. More information on the test protocol and on test results can be found in the reports [1],[2].

3. Performance test

The performance test of LOCOSTRA equipped with the GPT took place in Jabir test site, while the performance test of LOCOSTRA equipped with the vegetation cutting tool took place in Karama test site. Due to the fact that the test area in Karama was a suspected hazardous area, the performance test here coincided with the acceptance test of LOCOSTRA equipped with the mulcher.

LOCOSTRA equipped with the GPT was tested along one lane, as only one type of soil was available, where three different types of landmine wooden targets were previously buried at different depths. The lane was divided in three sectors and three fibreboards 3mm thick were buried into the lane at the beginning of sector A, between sector A and sector B and at the end of sector B. A total of 42 targets were used. According to the CWA 15044:2009, mine targets depth was measured from the top of the mine to the soil surface. Results are summarized in table 1.

depth	**target mines deployed**	**target mines removed**
0mm	11	11/11
5cm	11	9/11
10cm	11	0/11
10cm*	3	2/3
15cm*	6	5/6

Tab.1. LOCOSTRA and ground processing tool, performance test.

Results signed with the asterisks are relative to the third sector, sector C. Before approaching sector C, modifications to the length of the third point linkage connecting the GPT to the tractor were made to achieve a deeper soil processing.

Fig.2. Performance test of LOCOSTRA equipped with ground processing tool (potato digger).

4. Survivability test

The survivability test was done on the GPT mounted on LOCOSTRA. In order to be sure that the mine would be exploded by the tool it was decided to bury the live mines flash with surface underneath the GPT and activate them by the GPT weight, by lowering the three point linkage system (trough which the GPT is connected to the tractor) by remote control.

First a live M14 mine, containing 28g of Tetryl, was placed under the first blade of the GPT near to the left hand side (looking at the GPT attached to the tractor from the tractor). The mine was buried flush with surface. The engine was started and the three point linkage system lowered on the mine, remotely.

Secondly, a live M35 mine, containing 100g of TNT, was placed under the second blade of the GPT near to the right hand side. The mine was buried flush with surface. The engine was started and the three point linkage system lowered on the mine, remotely. Results are summarized in table 2.

live mine type	**damages**	**repairs**
M14	 The blade under which the M14 mine was placed bent 60mm upwards at the very tip. The blade near to it bent in the middle 15mm.	The blade that bent 60mm was removed and hammered back to its original shape in half an hour
M35	 The blade under which the mine was placed detached and was found 1.3m away from its original position, underneath the tractor. The lower right linkage was slightly deformed probably because hit by the blade.	The blade was placed back into its original position using new screws.

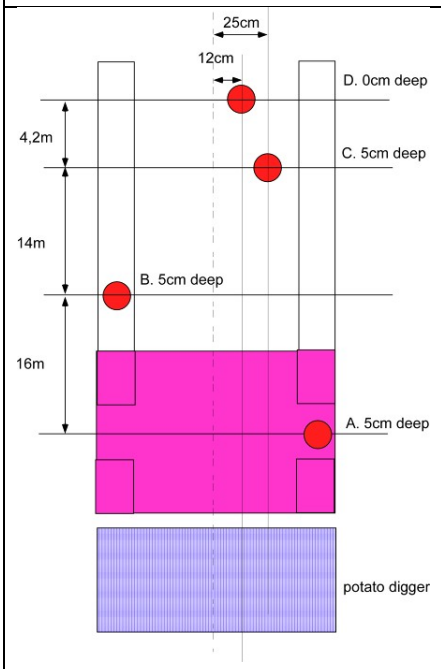
Tab.2. LOCOSTRA and ground processing tool, survivability test.

5. Acceptance test

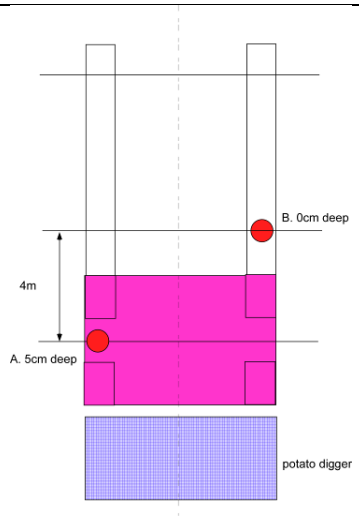
The acceptance test was divided in two major phases that took place in two different test sites. The first major phase was done in Jabir test site, where LOCOSTRA was tested in three lanes where live mines were buried at different depths: a lane where 4 M14 (28g of Tetryl) live mines were buried, a lane with 3 M35 (100g of TNT) live mines buried, and in a lane where 2 PMN (240g of TNT) live mines were buried. The three parts of the first phase were called phase 1.A, 1.B, 1.C. In the first two LOCOSTRA was tested equipped with the GPT, in the last one, phase 1.C, LOCOSTRA was tested alone, without attachments.

During the first phase, live mines were buried only at two different shallow depths (0cm and 5cm) in order to increase the possibility for the tractor wheels to actuate the mines and for the GPT to process mines. Moreover, this was considered to be the worst case scenario both for damages possibly caused to the wheels and the tractor and to the GPT. Test lanes were prepared in class I soil, the only type of soil

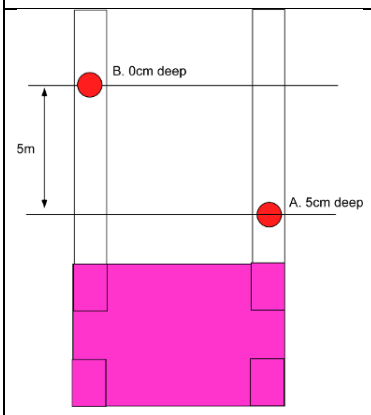
available in the Jabir test site, by running the tractor first on the test site to leave footprints on the soil and make it easier to dig the holes for mines in the right places. Holes were dug trying to disturb the soil as little as possible.
The second major phase was done in Karama test site, with LOCOSTRA equipped with the mulcher. The machine was used to clear vegetation and process the top soil in a suspected hazardous area (SHA) covered by low, medium and high vegetation.
The schemes of the test lanes of phase 1.A, phase 1.B and phase 1.C are reported in table 3, table 4 and table 5, together with results.

scheme	mine name	depth	mine location	result
	A	5cm	under rear right wheel	exploded by the wheel, without causing any damage
	B	5cm	under front left wheel	not exploded
	C	5cm	in between track footprints	exploded by the right wheel of the GPT, causing little damage to the wheel
	D	0cm	in between track footprints	removed by the GPT and left 65cm away from its original position. The mine was not damaged by the GPT

Tab.3. LOCOSTRA and ground processing tool, phase1.A of acceptance test.

scheme	mine name	depth	mine location	result
	A	5cm	under rear left wheel	not exploded, but later on removed by the GPT and moved 2.5m away from its original location
	B	0cm	under front right wheel	exploded by the wheel, without causing any damage

Tab.4. LOCOSTRA and ground processing tool, phase1.B of acceptance test.

scheme	mine name	depth	mine location	result
	A	5cm	under front right wheel	not exploded by the tractor wheel, even after more than 15 runs. Only exploded when a M14 mine was placed on top of the PMN and the tractor was driven over it. No damage to the wheel, except for a very light deformation of one lug. No need to maintenance for future work.
	B	0cm	under front left wheel	exploded by the wheel, Only small damage confined to the area where the explosion occurred. No need to maintenance for future work.

Tab.5. LOCOSTRA and ground processing tool, phase1.C of acceptance test.

LOCOSTRA equipped with the mulcher kindly provided by FAE – Advanced Shredding Technologies was tested along two days of work. Because of the availability of three different types of vegetation the machine was tested in all of them. Details of the test results can be found in table 6.

Vegetation type	n° of lanes processed	total area processed	time
low	3 lanes	75m2	149s
medium	3 lanes	100m2	240s
high	2 lanes	40m2	253s

During the test no explosion occurred. Personal protective equipment and protective boots were worn by the test team, a metal detector was used to check for the presence of mines while investigating the area processed, but no mine was found.

6. Conclusions

The overall result is very satisfying and proves that the innovative concept of LOCOSTRA is good: LOCOSTRA tractor equipped with agricultural tools readily available on the market can successfully be employed in humanitarian demining activities.

LOCOSTRA resisted well, without needing any repair four explosions, as described in figure 3. The worst explosion was the one with 269g of explosive. Also this last one didn't cause any damage.

The tests with the GPT opened up space for further study and a proposal on the possible application of agricultural tools in demining has already been written and submitted. Even if the GPT would benefit from further studying, it proved to be a very efficient tool for ground processing and mine removal. In fact, the GPT successfully removed mines down to a depth of 5cm without exploding them. When tested with target wooden mines, after adjusting the length of the third point linkage, it reached the working depth of 15cm. Damages recorded after the survivability test were very localized and easy to repair. The cost of the new bolts was 2.5€, the time to hammer back in original shape the deformed blade was less than 30min.

The combination of LOCOSTRA with the mulcher proved to be ready to be exploited in mine action activities. LOCOSTRA with the mulcher successfully cut low, medium and high vegetation up to small trees 15cm in diameter. Especially during the pre-test in Italy, where LOCOSTRA equipped with the mulcher was tested in forest-like area, the high agility and great efficiency of the machine could be appreciated. Thanks to the double steering system, the tractor could turn around the bigger trees (that generally do not have to be cut) and cut all the others. Moreover, the mulcher capacity to slightly process the soil was also appreciated, as it can be seen from figure 3.

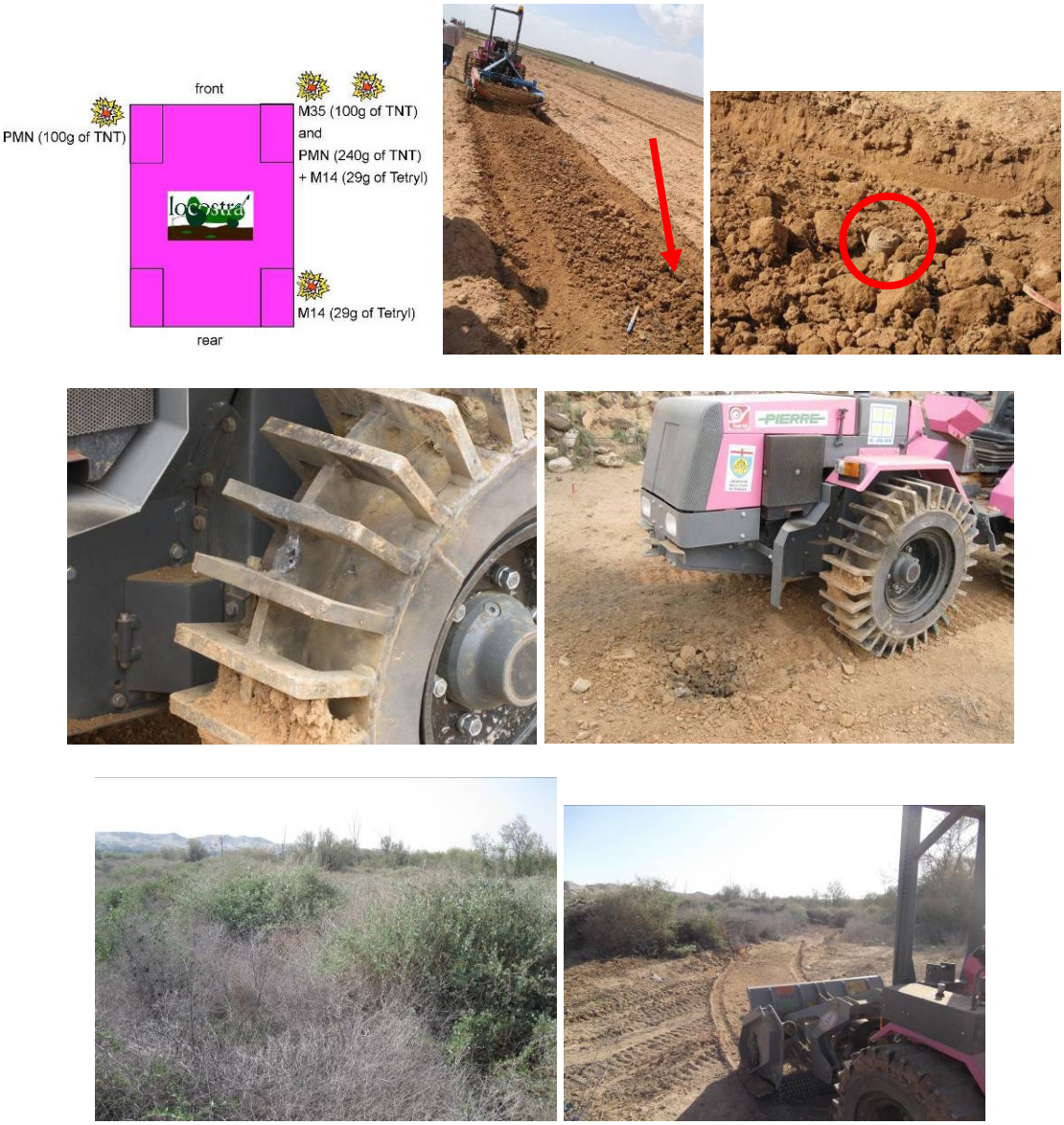


Fig.3. Explosions occurred under LOCOSTRA, an M14 mine removed and processed by the GPT without explosion, the worst damage caused to blast resistant wheels (very light) after a PMN explosion, medium vegetation before and after clearance.

7. References

[1] WP3_Task3.6_Deliverable_v5, LOCOSTRA in – field test protocol. Will be available soon on project website, www.snailaid.org
[2] WP3_Task3.9_Deliverable_v1, LOCOSTRA in – field test protocol. Will be available soon on project website, www.snailaid.org