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Disarmadillo: an open source, sustainable, robotic platform for humanitarian demining

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ABSTRACT
The mine action community suffers from a lack of information sharing among stakeholders. Since 2004, Snail Aid has been working on Disarmadillo, a dramatic shift in paradigm: an open source hardware platform for humanitarian demining. Developed mainly thanks to volunteers' work across more than 15 years, the machine is now going to get a push thanks to the project Disarmadillo+, in collaboration between Snail Aid - Technology for Development and the Italian Institute of Technology. The new version of the machine will be improved in terms of manoeuvrability, modularity, versatility, without compromising its characteristic features. The re-design will take into account the need of keeping the cost low and the technology appropriate to the context where it will work. The ability of the machine to serve two different purposes will also be preserved: the machine will keep on being easily convertible to its original agricultural nature, being developed around a commercial off-the-shelf powertiller. The paper presents the machine and the research work foreseen within the new project.

Section: RESEARCH PAPER

Keywords: Humanitarian demining; open source hardware; appropriate technology

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1. INTRODUCTION

"Peace agreements may be signed and hostilities may cease, but landmines and Explosive Remnants of War (ERW) are an enduring legacy of conflict", states, in its first sentence, the Landmine Monitor, a comprehensive assessment of progresses in eliminating landmines, cluster munitions and other ERW, published annually. According to [1], in year 2020 alone, the number of casualties of mines/ERW was more than 7000, with approximately 2500 people killed and the rest injured. Out of them, the majority (80%) were civilians, half of whom children.

At the moment, at least 60 states and other areas are contaminated by antipersonnel landmines. Among them, the countries considered to be massively contaminated (with more than 100 km^2 of contaminated land) are Afghanistan, Bosnia and Herzegovina, Cambodia, Croatia, Ethiopia, Iraq, Turkey, Yemen and Ukraine, with the latter recently bombed with cluster munitions [2]. Among these, many are also facing severe hunger, with Iraq, Afghanistan and Yemen having more than 34% of the total population undernourished, while Ethiopia more than 25% [3].

While the utmost importance of releasing land to local communities for food production and economic development is evident, the lack of intensive mechanization of the demining process surprises.

Disarmadillo represents a breakthrough sustainable innovation in mechanical demining technologies; it has been designed to stay behind when demining is over and serve long-term agricultural development of the country where it helped release land to local communities. It is affordable and being based on mature agricultural technology its maintenance and running costs are minimized. Instead of being designed to clear mines, it is designed to collect information about mine presence either from sensors and from light ground processing and vegetation cutting. Thanks to its low cost, more units can be used at the same time, helping release land to local communities faster. When not used in demining operations, Disarmadillo can be reconverted to its original agricultural use and help securing food production.

The paper is organised as follows. Section 2 introduces humanitarian demining and the machines currently employed in it, together with an overview of robotics solutions suggested for the task, highlighting shortcomings and possible improvements. Section 3 introduces Disarmadillo machine concept and the philosophy behind it. Section 4 is about Disarmadillo architecture, and Section 5 is about the features of Disarmadillo+, the new version of the machine under studying. Then, conclusions are drawn.

2. HUMANITARIAN DEMINING

Humanitarian demining methods are based on manual demining, a procedure in which mines are manually detected and neutralized by a human deminer, equipped with simple gardening tools such as shovels and shears, prodders and, if possible, metal detectors.

Manual demining is the most versatile and trusted method and therefore is present in every demining program. Sometimes, manual deminers work together with dogs trained to detect explosives contained in mines. When it is possible, demining machines help with the physical demining process phases, i.e., vegetation clearance, mine detection, and removal [4].

However, the number of machines in use is surprisingly low. An in-field study [5] conducted in 2012, across six organizations in six countries, recorded only 13 machines in use. The Geneva International Centre for Humanitarian demining (GICHD) electronic catalogue of mechanical equipment used for demining operations [6], currently reports only 40 machines in use: this is the sum of numbers of machines in use inserted by a single company producing four types of different machines, the other producers having not filled in this information. Although these data definitely do not represent the whole picture, they show that mechanization in this field is extremely limited.

Several reasons can be accounted for this issue, including lack of funding, the inability to move from Research and Development (R&D) to practical commercial devices, the cynicism of innovation by those convinced their current practices are entirely sufficient [7], the high cost of maintenance of complex equipment in mine affected countries [8] and the lack of information sharing among stakeholders.

TIRAMISU, D-BOX and Demining Robots are among the largest R&D projects that recently tackled humanitarian demining. While the first two ran in parallel and were both co-funded by the European Union (EU) within the 7th funding framework programme, the latter is still ongoing and is funded by Nord Atlantic Treaty Organization (NATO) Science for Peace and Security programme. Among them, only TIRAMISU and Demining Robots were explicitly aimed at developing new robotic vehicles, while D-BOX was focused on creating an Information Management System [9].

The Demining Robots project employs a multi-sensor robotic platform developed in a previous phase of the project and designed specifically for research purposes and testing innovative mine detection methods such as impulse ground penetrating radar [10]. The robotic platform, called Ugo-1st, is, thus, not yet suitable to be fielded in demining operations.

The TIRAMISU project led to the development of robotic vehicles at higher Technological Readiness Level (TRL), such as Teodor, Frs Husky and the Apt. The first is a tracked outdoor platform equipped with an array of five metal detectors, the second a four-wheel all-terrain vehicle equipped with an arm carrying a metal detector and an artificial nose, and the last is an improvement of the Locostra machine, a four-wheel agricultural tractor modified to be used in mine-affected areas [11]. These and many other robotic platforms designed for demining have been analysed in [12], which highlights the need to address several requirements other than the increase in safety of human deminers, such as the speed of robotic vehicles, the ability to operate over long periods of time in varied environments, the amount of payload they can carry and their cost-efficiency. Out of all platforms, [12] selects six for quantitative comparison across the identified requirements. Apart from Teodor, Frs Husky and Locostra, the comparison table includes:

- Ares, a four-independently-steered wheel vehicle [13],
- Silo-6 [14], a hexapod walking robot, and
- Gryphon –IV [15], a modified moon buggy vehicle equipped with a pantograph arm carrying a metal detector.

Apart from having better landmine detection/exposure results in field trials, Gryphon IV and Locostra are more promising in payload and operation time. Nevertheless, these two solutions have not found application in the field yet. This might be due to the fact that their development took place within R&D projects and was limited by funding available. An open-source approach would guarantee the community to take ownership of the technology and the development to continue behind research projects timelines.

The International Mine Action Standards (IMAS) [16] define demining machines as machines designed to be used in hazardous areas. They are divided into machines designed to detonate hazards, machines designed to prepare the ground, and machines designed to detect hazards. Machines belonging to the first group are generally heavily armoured, highly powered and very expensive to purchase. They achieve mine detonation by processing the soil at high speed with spinning tools at the front aimed at crashing or hitting whatever they encounter, thus using a large amount of power, delivered by large and high fuel consuming engines.

While most machines on the demining technology market belonged to this first type in the past, recently there has been a shift toward smaller sized [7], less powerful machines designed to prepare the ground other than detonate hazards. Ground preparing machines are primarily designed to improve efficiency of demining operations by reducing or removing obstacles.

The size of machines has been decreasing over time answering the need for more appropriate technologies, being the logistics of heavier ones very difficult in post-conflict scenarios, at the same time, a limitation of the practical in-field use of heavier and more powerful ones, has been acknowledged. A study [5] (Figure 1) has shown that the efficiency of these machines in terms of mine detonation is well below expectations and, therefore, in most cases another mine clearance asset, usually manual deminers or mine detection dogs, has to follow the machine and complete its task.

The shift toward smaller machines has occurred along with a change in paradigm aiming to employ resources more efficiently. The *land release* process has been promoted and is now largely employed to reduce time by which Suspected Hazardous Areas (SHAs) are released to local communities. According to [16] mechanical land release involves a machine being used to indicate or confirm the presence or absence of landmines and/or ERW within a suspected or confirmed hazardous area. The aim is to enable the deployment of other demining assets only in areas

Figure 1. Results from the same demining machine. On the left, test lane used in test site in Germany with dummy Antipersonnel (AP mines), called WORM, 0 cm – 20 cm deep: 98.22 % neutralized. On the right hand side, suspected hazardous area in Angola: 10 AP mines processed and left live intact (of type POMZ and PP-MI-SR).

proven to contain landmines and/or ERW including unexploded sub-munitions.

In other words, machines to be employed in mechanical technical survey mainly need to verify the absence of mines in the given area; if they encounter an explosion, the area needs to be re-categorized and further processed. This means that machines used in technical survey need to process the ground and to resist, or not to be severely damaged by, only one explosion at time, while keeping the operator safe.

Although recent trends allow introducing smaller, lightly armoured and powered, more cost-efficient machines, designed to perform multi tasks in ground preparation, and major steps have been taken towards this direction, there are still progresses to be made.

Figure 2 reports the size and power of demining machines available now. Data have been extrapolated from the GICHD electronic catalogue and from websites of manufacturers that recently exhibited their equipment in conference venues. As can be seen, the average weight of demining machines available on the market is still above 10 tonnes, and the average power is 300hp.Going smaller and more versatile might be not only useful for humanitarian demining, allowing the number of machines in use to increase, but also, in light of reconverting demining machines to food production, for sustainable agricultural mechanization. In fact, according to [17], about 90 % of farmers worldwide operate on a small scale, and the technology must become accessible to this large group. Reference [18] highlights as a key factor for the successful adoption of agrobots in developing countries the capacity to design and offer technical solutions at a low (affordable) cost but with a high impact. Again [18] estimates that small robots at an affordable price for purchase or hire represent a potential alternative in areas where manpower is scarce and conventional machinery is not available or is too costly for smallholders.

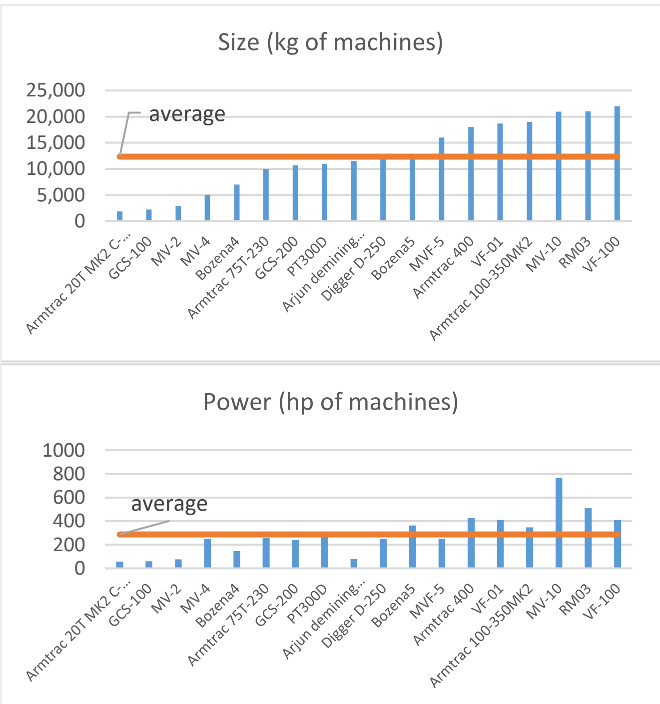


Figure 2. Size (*top image*) and power (*bottom image*) of demining machines currently on the market.

3. DISARMADILLO

The work on Disarmadillo machine started in 2004 with a one-month long visit to mine action activities in Sri Lanka. During the trip, groups of deminers were interviewed to start the research in the right direction, better understand local needs and establish a reciprocal trust between local people and researchers. Most notably, information was gathered by working on the functional requirements for a system of demining machines to work close to the deminers. When deminers were asked about their preferences for new machine technology, they expressed a strong desire for new machines that were small, light and inexpensive. They wanted machines to help in the most boring/difficult parts of their job, particularly cutting vegetation and processing the ground, especially the hardest one, scarified using a simple rake called heavy rake, according to local procedures, to remove the soil hiding mines [19].

Based on these findings, the first version of Disarmadillo machine, called Participatory Agricultural Technology machine (PAT machine) was built within the first author's PhD work [20].

The work on Disarmadillo continued over the years thanks to the contributions of volunteers of Snail Aid, a non-profit organization, and students of a secondary technical high school in Genova, Italy, who devoted part of their time to improving the machine and building parts of it in the school mechanical workshop. Disarmadillo is, in fact, conceived to be appropriate

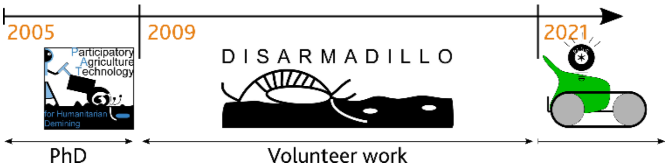


Figure 3. Disarmadillo evolution over time.

to the local context, and thus, components have to be suitable to be produced in not specialized workshops.

In 2021, Disarmadillo+ project has been approved assuring a push forward thanks to the collaboration between researchers of the Italian Institute of Technology and Snail Aid – technology for Development (Figure 3).

The core idea behind Disarmadillo is to adapt power tillers to demining applications. Power tillers are small agricultural machines widely used and commercially available in many mine-affected countries and their second-hand market is largely spread. They are easy to transport as they are small and light, and they are available with different types of engines. The most powerful one (approximately 14 hp) is sturdy enough for being employed in several versatile tasks, from ground processing to vegetation cutting.

Power tillers, also known as walking tractors, two-wheel tractors or iron buffalos have a great importance in their nations' agriculture production and rural economies. They not only have rotovator attachments but also mouldboard and disc-plow attachments. Seeders, planters, even the zero till/no-till variety can be attached. Reaper/grain harvesters and micro-combine harvesters are available for them. Also very important is their ability to pull trailers with over two ton cargoes.

The population of powertillers in developing countries is surprisingly high. China has the highest numbers estimated to approach 16 million, Thailand has nearly 3 million, Sri Lanka 120,000, Nepal 15,000. Parts of Africa have begun importing Chinese tractors, and Nigeria may have close to 1,000. Many countries of Central/Eastern Europe also have significant populations of 2-wheel tractors, as they have been sold there for agricultural use since the 1940s [21].

3.1. Disarmadillo philosophy: open source

Among all of the reasons that might be found behind the scarce employment of machines in humanitarian demining, in authors' opinion is predominant the lack of information sharing.

Often, researchers into new technologies for mine action do not have access to useful information being generated in the field that is treated as proprietary and not shared [22] unless after an extensive and deep personal analysis, often involving field visits that generally require important resources to be committed to the cause. At the same time, machine producers tend to market their products in the same way as military equipment, negotiating their sales, including price, in confidence. The lack of transparency of the market makes comparing the cost-efficiency of machines difficult, and the introduction of new systems not perceived as necessary.

Therefore, in order to create a favourable environment for more technologies to enter the demining technology market, there is need to change approach and create a more transparent, less donor-depending and more cost-efficiency oriented market. Disarmadillo is aimed to be an upgrade kit that can be mounted on every type of powertiller to transform it into a demining machine supporting manual deminers in their work. When not used in demining operations, Disarmadillo can be reconverted to its original agricultural use and help secure food production.

While Commercial Off-The-Shelf (COTS) components needed by the kit will be listed with price and suggested purchasing sites, all components that need to be custom made will have their technical drawings available for free downloading from the internet. Potentially, a new machine could be built around any powertiller by anyone interested, with as few modifications as possible.

Similar approaches are being successfully used by projects targeting electronics (Arduino) and heavier hardware (open source ecology or Do It Yourself (DIY) Vehicles or Drones). As in these well known cases, the community of users would be asked to provide its feedback on experiences with the machine and contribute to future developments.

The idea to adopt an open design business model for a mine action technology is provocative and runs counter the current trends in the Humanitarian Mine Action (HMA) market highlighted in the previous part of the paper; nevertheless, it is feasible and profitable. If required by customers, all parts needed could also be delivered in a box to the customer. If necessary, upon request from the customer, assembly of all components can also be offered as a service locally (as knowledge transfer) in the mine affected country together with training on the use of the machine. Thanks to its modularity, if the community devises new tools or components, old machines can be upgraded without having to jettison what works.

This approach aims to challenge the traditional lack of information sharing of mine action and increase the active participation of end users in the design and decision-making process. Positive implications are expected in terms of bridging the gap between scientific and operational HMA communities, increased competition level, cost reduction and possibly promotion of a closer integration with development.

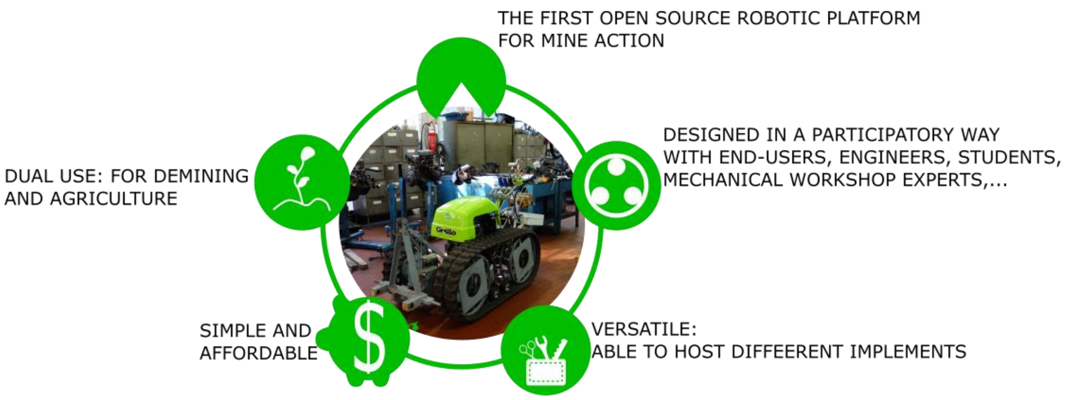


Figure 4. Disarmadillo philosophy.

3.2. Disarmadillo philosophy: versatility

Disarmadillo is a robotic platform designed to carry different tools. Some have already been tested, some are designed and others are still in the form of ideas. Thanks to the open nature of the project, partners have tested tools locally, such as the vibrating sieve, developed by prof. Ross Macmillan in Australia. Figure 5 depicts the tools conceived for Disarmadillo and available on Snail Aid website (top image) and, as an example of them, the *rake* (bottom image). The *rake* is designed for ground processing in loose soils, where manual deminers use rakes to uncover the ground and expose mines. It penetrates the soil in front of the machine, cuts it and sieves it by lifting mines and leaving them besides for later collection by deminers. A prototype has been manufactured and successfully tested in Jordan with dummy mines.

3.3. Disarmadillo philosophy: demining and agricultural purpose

As their job is to process the ground, agricultural machines originally conceived to work the soil could be efficiently employed in demining.

Since landmines impact food security via six different and somewhat reinforcing mechanisms, including access denial, loss of livestock, land degradation, reduced workforce, financial constraints and aid dependency [23], it makes sense to introduce (in mine-affected countries) multi-purpose technologies that can serve not only to demine but also for food production.

Agricultural technologies are mature and simple, easy repairable in every developing country in local, not specialized workshops. The modularity of agricultural technologies is another advantage; the same tools can be mounted on different tractors units and replaced by dedicated agricultural tools when demining operations are over. Moreover, involving local technicians in re-designing new or improved technology helps reduce the dependency of local communities on donors' help and facilitate local human development. Empowerment is an integral part of many poverty reduction programmes. Helping individuals and communities to function as agents for improving their well-being is essential for promoting human development and human freedom. Empowerment shall not depend only on state-funded resources and opportunities but also on citizens taking responsibility for self-improvement. The handover of all mine action activities to local entities who can perform the majority of the work and gain skills while participating in the creation and maintenance of new agricultural technology for area reduction is desirable and necessary.

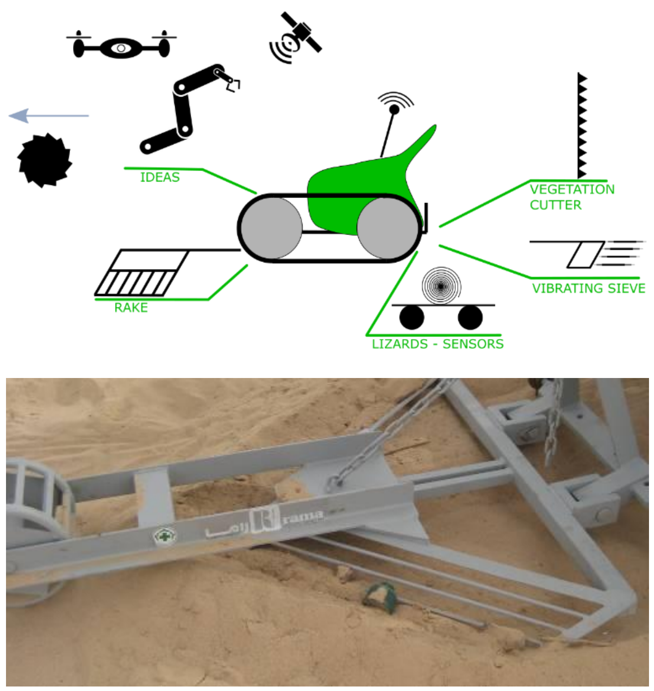


Figure 5. Disarmadillo tools (*top image*) and a picture of the *rake*, tested in Jordan with dummy mines (*bottom image*).

The development of sustainable agricultural technologies and their transfer and dissemination under mutually agreed-upon terms to developing countries, is encouraged by Food and Agriculture Organization (FAO) [18]. FAO also stresses the importance of supporting national efforts to foster the utilization of local know-how and agricultural technologies, to promote agricultural technology research to increase sustainable agricultural productivity, reduce post-harvest losses and enhance food and nutritional security.

Centres could be built with the double aim of renting and servicing machines both for humanitarian demining and agriculture, therefore representing a major step toward the integration of demining and development and the transition to local ownership, wished for since a long time.

By introducing facilities where to adapt agricultural tools to demining activities, we can support R&D in agriculture. Machinery could be provided as and when needed on a custom hire basis to the small and medium farmers who cannot afford to purchase their own machinery. Similarly, in parallel to agricultural machines, the agro service centres could also provide machines for technical survey, based on agricultural machines. They could develop the modifications required to effectively address the demining problem locally, then hire these machines and provide assistance.

As confirmed by current trends, today, in both developed and developing countries, the availability of human resources for farming is decreasing due to labour shortage both for lack of interest from young people and for weak or aging farming workforce: this means that a single worker (sometimes weak) is often in charge of large extensions of land. These factors influence the development of local agriculture and open a market share for automation also of small machines (mass lower than three tons). Differently from heavy tractors, small machines with competitive costs cannot be effectively developed simply by modifying existing manual driven models: their architecture should be rethought for automation [24].

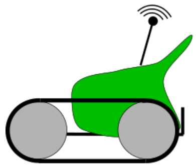
4. DISARMADILLO ARCHITECTURE

The current version of Disarmadillo (Figure 6.c) is built around a powertiller (Figure 6.b) produced by Grillo Spa (www.grillospa.it), which kindly donated it to the project, together with spare parts and suggestions. The technical features of the power tiller and the constructed Disarmadillo prototype are summarized in Figure 6.a.

The kit adds to the original powertiller a frame (Figure 7), which has the dual aim of hosting two additional wheels at the front with respect to the original driven wheels and of embedding a track tensioning system. The frame is made of standard steel profiles, easy to build and maintain requiring only cutting and welding operations.

Agricultural tyres are replaced with special wheels designed to transmit motion to and support the tracks along their width. The frame added to the power tiller is designed to host a winch and a sort of three-point linkage system, allowing different tools to be

TECHNICAL DATA (based on Grillo G131 powertiller)



DIMENSIONS	ENGINE DATA	FEATURES
length: 2500mm width: 1000mm height: 1300mm mass: 500kg	type: Lombardini Diesel 3 LD 510 4-stroke air cooled power: 9kW - 12,2hp fuel consumption: 250g/kWh	control system: remote and manual (safe areas) power take off differential skid steering reversible drive 4 forward gears, max speed 7km/h 2 rear gears, max speed 3,5km/h

a)

b)

c)

Figure 6. a) Technical data of Disarmadillo machine based on G131 powertiller produced by Grillo. b) The original powertiller and c) Disarmadillo as it was exhibited at the 7th Mine Action technology Workshop in Basel in 2019.

mounted at the front. The power take-off at the back of the machine can be used to power implements requiring an actuating torque. Being reversible, the machine can be used indifferently forward or backwards. The machine is remotely actuated and is driven by an industrial remote-control unit, allowing major functions to be controlled remotely (Figure 8). The remote control system is not substituting original manual controls; therefore, once reconverted to agricultural activities, the machine can go back to manual control.

The platform rotates thanks to differential skid steering, thus by braking one of the two stub axles through which power is transmitted to the wheels through the differential gear. External band brakes are mounted on the frame, acting on the stub axles. A linear electric motor actuates each brake via cable, actuating a lever. Power for the electrical motors is derived from the battery on board.

The power take-off at the back of the powertiller, accessible through the frame, can be used to power tools that need a torque.

5. DISARMADILLO+

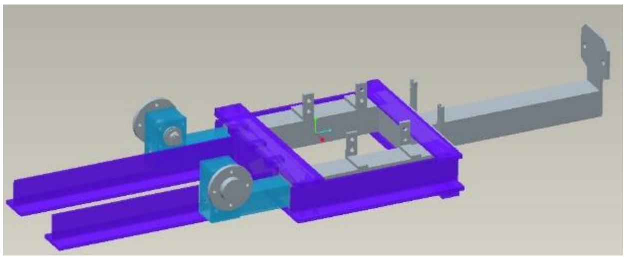
The Disarmadillo machine has been subject to continuous research by Snail Aid and partners on a volunteer basis for the last fifteen years; its latest version was presented to the community during the 7th Mine Action Technology workshop in Basel in November 2018 raising considerable interest. The Disarmadillo+ project will bring it to a higher level of maturity.

Major improvements are envisaged in terms of:

- **Manoeuvrability and reliability**, by actuating wheels with independent hydraulic motors and not any more through the differential gear powered by the internal combustion engine.

Each of the hydraulic motors, one per side of the machine, will be connected to a hydraulic pump actuated by the endothermic motor in a closed-loop circuit (Figure 9). This new architecture would allow a narrower turn radius, and more efficient turning by actuating the two motors in opposite directions. Moreover, it would allow driving the machine backwards without rotating it or changing configuration before operations start.

- **Modularity**, by splitting the frame into two parts, each portable by two persons, for easy conversion from one configuration (demining) to the other (agriculture). Moreover, it is foreseen to change the points of attachment of the frame to the powertiller to reduce the number of ad-hoc flanges necessary



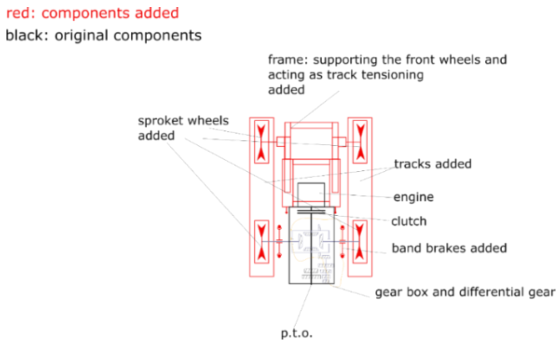


Figure 7. Scheme of Disarmadillo: red parts, frame, wheels, tracks and band brakes are added to the original powertiller (black).

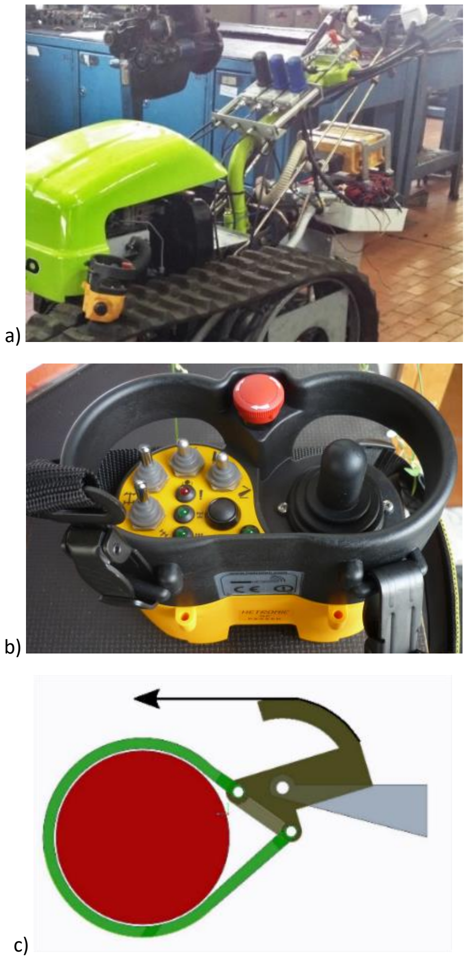


Figure 8. Particular of the control unit: a) linear motors actuating brakes and the clutch, b) transmitter and c) 3D model of band brakes leverage.

to adapt the kit to different types of powertillers, exploiting the power take-off, with a pass-through system, and the axles.

- **Human machine interface**, by improving the remote control transmitter interface to expand its possibilities and make the driving more intuitive.
- **Versatility**, by investigating the possibility to study blast resistant tracks, building up on experience gained on blast resistant wheels developed for a larger machine for humanitarian demining based on a four-wheel tractor called Locostra, developed by Snail Aid and other partners [25].

In fact, although explosive tests on a powertiller have been carried out in Italy [26] and no damages have been recorded to the drive train, wheels were damaged, making maintenance necessary in case of an explosion. A solution to increase the machine's protection is to mount a front roller when the operating tool is mounted at the back. Another option would be to design blast-resistant tracks that would allow retaining enough tractive integrity after an explosion occurs underneath them to continue working or to enable the withdrawal of the machine from the field for maintenance. A research [27] carried out in the 70's exploited successfully three design principles: shock absorption by the roadwheels (embedding circular epoxy-resin rings between the hub and the rim), an almost unbreakable chain of tractive effort, and sacrificial track pads designed to fly away.

A possibility would be to combine these ideas and the shock absorption exploited in Locostra wheels, achieved thanks to solid rubber inner wheels embedded in steel frames, and design solid rubber roadwheels and steel track elements allowing ventilation.

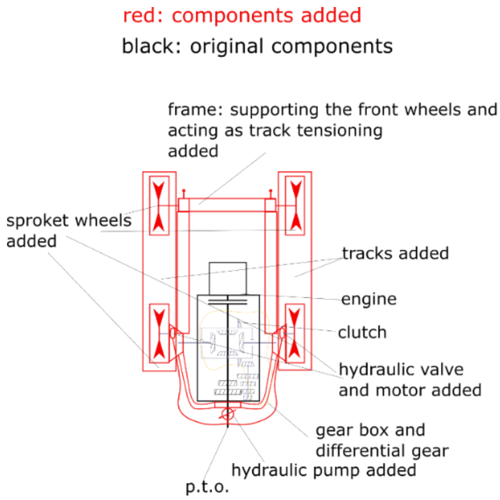


Figure 9. Disarmadillo+ scheme.

Disarmadillo+ will offer the occasion to investigate in new tools, such as a ground driven/aerial platform: a drone borne sensor platform connected to Disarmadillo+. The connection would be by tether or by another means allowing transmitting power from the ground rover to the drone, permitting long lasting flights and transferring data from the drone to the rover.

Importance will be given to keep complexity and cost low. As generally acknowledged and well explained by Hemapala [28], when the price to performance ratio is too high, robots are academic toys.

To keep the cost and complexity low, the machine will be automated gradually, according to needs. At the beginning, it will be remotely controlled. Cost is also a key factor in the successful adoption of agrobots in developing countries, as stated by [18] that points out the need to design and offer technical solutions at a low (affordable) cost but with a high impact.

The final shape of the Disarmadillo+ machine is in the form of a remotely controlled tracked vehicle able to carry different tools. Recently, there has been an increase in the supply of small remotely controlled platforms designed to perform agricultural tasks. It is interesting to analyse these types of machines available on the market in terms of size and power, as was done for demining machines. These small-size agricultural machines are sold on a much transparent market than the one of demining machines, so their cost can be obtained from producers' websites or by browsing the internet, both for new products and second hand ones.

Figure 10 reports an analysis of 25 machines of this type according to their size and power; for few representative ones, also the cost is reported. As can be seen, the average size and power of these agricultural machines is much smaller than the one of demining machines. Indeed, their weight is almost an order of magnitude lower than demining machines, and their rated power is approximately six times lower.

The smallest of these agricultural machines, RC-751, produced by a Danish company called Timan, is comparable to Disarmadillo+ in terms of weight and power.

Apart from being designed with a different philosophy, not for operating in hazardous areas, and having a higher cost (it is sold approximately at 20 k€), it offers a good reference, showing that machines with such a small size can successfully be employed in many agricultural tasks. Moreover, the adoption of tools available for the RC-751 could be investigated also for Disarmadillo+.

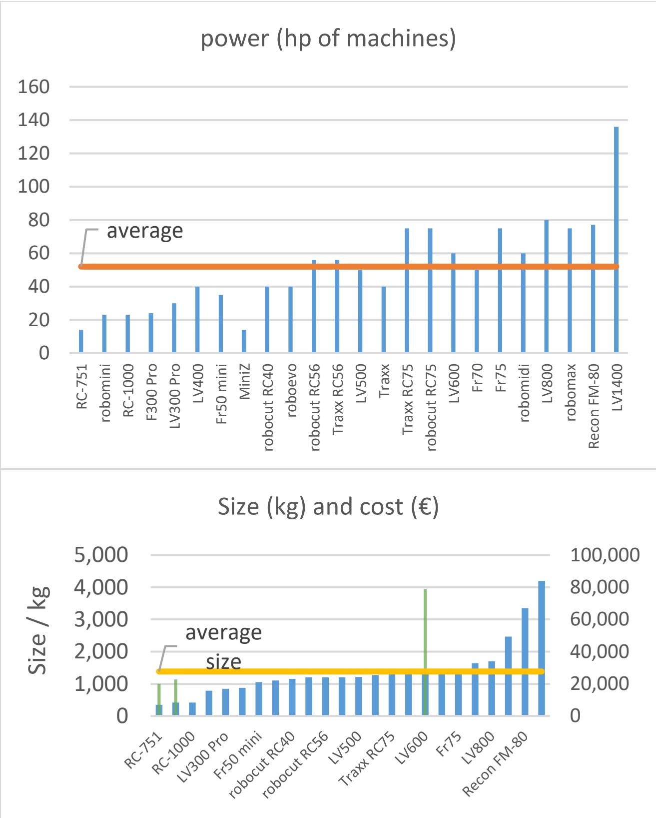


Figure 10. Power, size and cost of remotely controlled agricultural multi platforms currently on the market. In the last graph green bars indicate cost.

6. CONCLUSIONS

Considering the increasing consensus on the fact that mine action should be regarded as a development activity, there should be a rapid change of the current approach. The paper summarises some topics in this domain and introduces the design of a simple modular machine for assisting mine removal through ground processing and vegetation cutting. The tractor unit is chosen in the agricultural machines domain (power tillers), so as to assure full consistency with the local expertise and habits. Cost and sophistication minimisation are primary objective of the project.

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