Open source hardware for mine action

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Abstract

The mine action community suffers from a lack of information sharing among stakeholders. Although the problem has been highlighted long time ago by different practitioners such as [Lokey, 2000], it seems it hasn't been solved yet with reluctance in sharing basic data such as machine purchasing cost still actual (see the GICHD catalogue of mechanical demining equipment[2]).
An idea investigated and originally developed in 2004 with the Participatory Agricultural Technology (PAT) machine project is now revisited and re-proposed to promote a dramatic shift in paradigm: the development of open source hardware, especially mechanical technology for mine action.
Positive examples of business models already exist in open design. Learning from experiences by successful pioneers such as Arduino[3], a new philosophy is proposed in which demining technology is designed in a way that aims at making it suitable to be produced, or when this is not possible, to be assembled, in not specialized workshops around the world, and the detailed technical drawings are published on the internet under creative commons licenses, free to be downloaded by everybody interested in building the hardware.

The market of demining machines

The market of machines for demining is definitely of niche type, with less than 750 units currently operating worldwide. According to the Catalogue of Demining Equipment Catalogue[4], an electronic database hosted by the Geneva International Centre for Humanitarian Demining (GICHD) and continuously updated directly by machine producers, among the 43 different models of demining machines of all types produced, the majority (53,49%) are operating worldwide in five or less units (see fig.1). Nine different machine models have only one unit currently operating. Therefore, the market is characterised by a relatively high number of machine producers (29) each one with a limited number of machines in use in the field. Among the four companies with the highest number of units in use, the one with highest number (220) have them operating predominantly within the military (see fig.2).
Given that there is widespread consensus on the benefits machines bring to a faster release of suspected hazardous areas to local communities, there is huge potential for the market to expand. On the other end, clearly, some limitations to its expansion also exist and they should be looked for in the unique nature of this very particular type of market.
According to [GPC International, 2002] the market for humanitarian demining technologies is anything but traditional and does not respond to standard market approaches. The main reason for this is that it's small and donor-driven. Since the volume of the market is low and donors are asked to purchase the equipment users need, it is generally inefficient and conservative; decisions not necessarily reflect a cost-benefit analysis, instead favouring the use of well-known equipment, generally high cost.
The negative effects of a donor-driven market are also highlighted by [Bilec-Sullivan, 2007] who suggests that mine action personnel may only consider new technologies when it has been developed by a benefactor or a partner organization of a benefactor. For example, if a mine action operation is funded by a specific donor, the donor may require the use of a specific close-in detection technology developed by a partner organization. The potential result could be that technologies are sometimes adapted by demining organizations as a result of political or strategic partnerships versus increase in productivity or cost-effectiveness.
Another factor hampering the opening of the market is highlighted by [Lokey, 2000] who reports general reluctance by "experts" to share the information they have : information that could be used to benefit the entire community is frequently held by the expatriate and international workers who feel they're experienced experts and don't deem the hordes of

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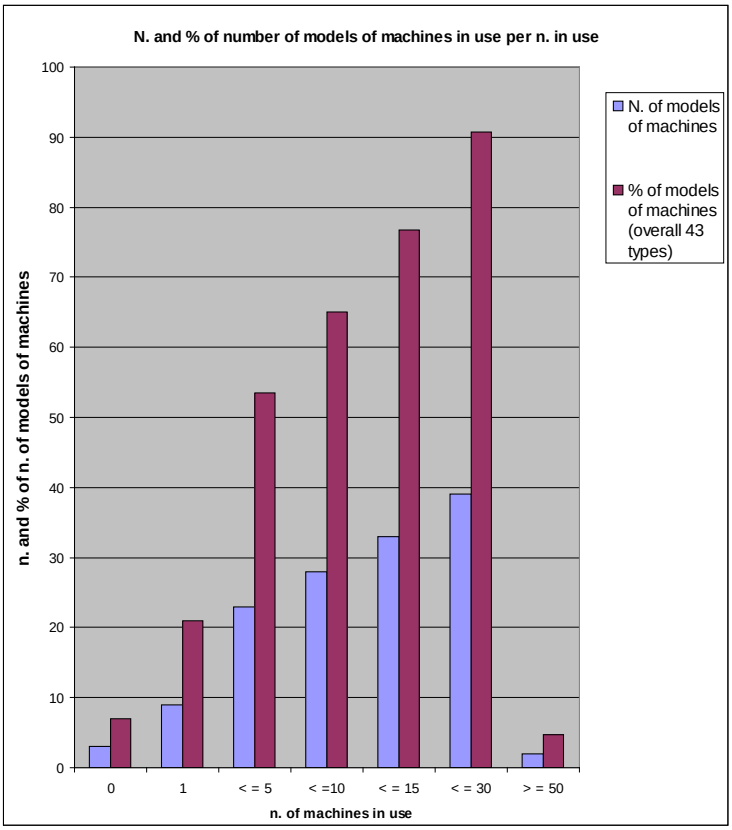
[2] [4] http://www.gichd.org/mine-action-resources/equipment-catalogue/#.VQg9htLF_1E
[3] http://www.arduino.cc/

newcomers worthy of their time and [Carruthers and Littmann, 2001] who observe that there is a great amount of potentially useful information being generated, but it is treated as proprietary and not open for dissemination.
The lack of information sharing and transparency is also responsible for keeping the gap between scientific and operational mine action communities very large and for making research into new technologies for mine action useful only if carried out after an extensive and deep personal analysis of end-user needs, that generally require important resources to be committed to the cause.



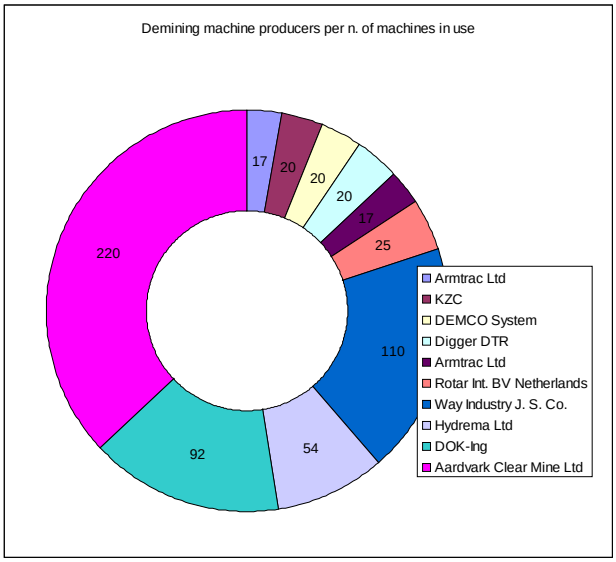


Fig. 1 and Fig. 2. Analysis of data published in the Catalogue of Demining Equipment published by the GICHD as of 12/03/2015.

Therefore, in order to create a favourable environment for more technologies to enter the demining technology market and then ultimately helping releasing mine affected land to local communities for a safe use including food production faster, there is need to change approach and create a more transparent, less donor depending and more cost-efficiency oriented market. While changing the market is a huge effort at which Snail Aid together with other partners is working on within TIRAMISU[5] project, creating a new business model for a new technology is easier. The hope is that the new model can work as provocative and pioneering example for other technology designers.

Disarmadillo approach

Snail Aid is a research and development not for profit organization that had the rare chance to have the time, resources and aptitude to gain the necessary experience in the field to achieve a fairly good understanding of the needs for new mine action technology. After having visited more than 30 organizations working in the field and having interviewed representatives of them at different levels in the context of different studies and visits during personal free time, Snail Aid staff has decided to suggest again an idea investigated and originally developed in 2004 with the Participatory Agricultural

[5] Toolbox Implementation for Removal of Antipersonnel Mines, Submunitions and UXO (TIRAMISU), is an EU co-funded integrated project (under grant agreement n. 284747) whose purpose is the creation of a comprehensive toolbox for humanitarian demining (TIRAMISU.http// www.fp7-tiramisu.eu/).

Technology (PAT) machine project [Cepolina E.E., 2008]: the development of open source hardware, in particular mechanical technology for mine action.

As PAT machine, also its newer version Disarmadillo is aimed to be an upgrade kit that can be mounted on every type of powertiller (a two wheeled agricultural machine used as prime mover) to transform it into a demining machine supporting manual deminers in their work, by helping them cutting vegetation and smoothing the soil before they start working. Instead of being designed to clear mines, it is designed to assist manual deminers or dog handlers (whoever follows the machine) by processing the ground in front of them with the double aim of making their work safer and lighter, but without pretending to detonate or crush all mines. Thanks to their low cost, more units can be used at the same time, helping releasing 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.

While COTS (commercial off the shelf 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 little modifications as possible.

Similar approaches are being successfully used by projects targeting electronics (Arduino) and heavier hardware (open source ecology[6] or Do It Yourself (DIY) Vehicles[7] or Drones[8]). 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 of revisiting PAT machine follows a stream of thoughts generated by the recent interest in a new standardised test protocol on demining machines other than machines designed to detonate mines. The current CEN Workshop Agreement (CWA 15044) regulating the test and evaluation of demining machines is openly biased towards demining machines designed to detonate hazards and clearly states that “there is need to expand future work to address a number of issues, including appropriate testing for ground preparation devices”. In the attempt to bridge the gap left by the current CWA, research into new protocols for testing and evaluating demining machines, other than machines designed to detonate hazards, has started and the possibility to take this opportunity also to integrate a cost-efficiency evaluation of such machines has been considered. To push the focus on cost-efficiency to an extreme, the idea of suggesting again a machine at near to zero purchasing cost, built around a typical available machine in rural communities, arose. Besides having negligible initial cost, Disarmadillo is characterised by being simple and modular. If required by customers, all parts needed could also be produced and bought in Italy by the producer and 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 new tools or components are devised by the community, old machines can be upgraded without having to throw away what works.

The kit adds to the original powertiller a frame that 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. 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 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. The remote control system is not substituting original manual controls; therefore, once reconverted to agricultural activities, the machine can go back to manual control.

Disarmadillo is aimed at hosting a range of different implements such as vegetation cutting and ground processing tools such as the rake (fig 5) that has already been tested in operating environment in Jordan with inert mines, while explosive tests have taken place in Italy [Salvi M. et al., 2005].

Disarmadillo has been designed in accordance with circular economy philosophy [Ellen McArthur Foundation, 2013]: the mature technologies it is based on are well known everywhere in the world as well as the skills needed to repair it. The machine uses components that are either available off the shelf or easy to manufacture in non-specialised workshops.

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[6] http://opensourceecology.org/

[7] https://www.osvehicle.com/

[8] http://diydrones.com/

Fig3 – 4 - 5. From left: DISARMADILLO built around a Grillo powertiller and DISARMADILLO built around an old Pasquali powertiller, rake implement under test in Jordan.

Thanks to the fact that it is based on mature agricultural technology also its maintenance and running costs are minimized.
The ambitious project idea is to make humanitarian mine action (HMA) end-users closer to technology providers, to allow end-users to choose and buy the technology they need without having donors as intermediate and to make them owner of the technology they use. By focusing on cost-efficiency of machines, the project aims at bringing sustainable technologies to developing countries to serve both humanitarian and food security.
The idea to adopt an open design business model for a mine action technology is clearly provocative and against the flow considering the HMA market trends highlighted in the previous part of the work; nevertheless, it is feasible and in line with Snail Aid's nature and mission.
This approach aims at challenging the traditional lack of information sharing of mine action, at increasing active participation of end users to the design and decision making process. Positive implications, as better explained in the following paragraph, are expected in terms of gap reduction between scientific and operational HMA communities, increased competition level, cost reduction and possibly promotion of a more close integration with development.

Open source hardware business model

Although it might seem controversial, open source philosophy can be a viable business model.
Open source could improve enterprise's performances by different perspectives. It could be seen as a development methodology to implement the open innovation paradigm, allowing the opening of the company's boundaries to the external environment, "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation" [Chesbrough, 2006]. Sharing problems and ideas, promoting collaboration and cross fertilization contribute to boost innovation, collecting inputs from all over the world, actively involving end users from the first design phases and at the same time it allows to save critically scarce resources like time and money.
The open source approach allows producing better products: an open product can be easily tailored and personalized, thanks to continuous consumer and technicians interaction; openness makes products adaptable and flexible (to local contexts, needs and budget) and easier and cheaper to maintain, to repair and individual parts easier to be reused [Gibb, 2015]. At the same time, products are available at low price or even for free. Based on the DIY Drones and Arduino case studies [Gibb, 2015], people can download free hardware design, the complete list of all the components (with relative prices) and the instructions on how to put them together to obtain the final product. Customers can decide to pay the company to make the product for them, to buy components by different suppliers and assembly autonomously or to do it by themselves.
Thus, open design has interesting positive implications in terms of sustainability mainly linked to the modularity of the products, the distributed manufacturing model [Wittbrodt et al., 2013] and postponement supply chain management strategy [Chang et al., 2010], resulting in close to zero waste manufacturing processes, compressed supply chain and long lasting of products life.
Finally the open source model seems to be actually coherent with the nature of Snail Aid, a no profit social enterprise researching and implementing technologies for sustainable development, both in Italy and abroad, especially in developing countries. The open source model tends to distribute wealth to the populace rather than to concentrate it [McKnight, 2010] and it works as business accelerator, encouraging business start-ups for new applications, minimizing barriers to entry.

Apart from the well known cases of Arduino and open source ecology, there is a great amount of other positive examples of application of open source models applied to hardware production. A plethora of DIY examples exist such as the already mentioned drones and vehicles.

Conclusions

The paper addresses the problem of lack of information sharing and transparency in the mine action technology world. A new paradigm is provocatively presented and a new business model suggested through the example of Disarmadillo, the first open source mechanical demining technology that would soon enter the market.

Acknowledgments

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