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3D printing humanitarian supplies in the field

News and Press Release

Source: ODI - HPN(/organization/odi-hpn)

Posted: 9 May 2016

Originally published: 1 Apr 2016

Origin: View original

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Anyone working in the field long enough will have experienced the frustration of failed supply chains, the backbone of all aid operations. Simply getting necessary items where they need to be at the right time is exceptionally challenging where uncertainty and disrupted physical and communications infrastructure mean that procurement orders, even for simple items, can take weeks or months to fulfil. Yet relief efforts need more than just lots of basic items. They also need individual 'one-offs', such as replacement parts for medical equipment or machines. Logistics are also expensive, accounting for an estimated 60–80% of costs related to humanitarian aid. These demands require novel approaches to making aid more efficient that go beyond incremental supply chain innovation.

Field Ready

Field Ready uses partnerships and capacity-building to provide sustainable hyper-local manufacturing of essential supplies in the field.+ With support from the Humanitarian Innovation Fund, we use agile and iterative techniques and practices drawn from technology start-ups. This approach allows us to try new ideas, evaluate them quickly and adapt them for the contexts we find in the field. One way we are doing this is by extending the potential of 3D printing (3DP) in the field. Our approach involves making and testing designs closely with the people who will use them (including affected people and relief workers – anyone who might come into contact with the final product or item), reducing the risk that too much is invested in an inappropriate design or in solving an unimportant problem.

As Field Ready is pioneering 3DP in disaster relief, we have also put heavy emphasis on working in partnership and passing on skills to others. We are working with other initiatives, such as the ICRC's 'RedLabs', Refugee Open Ware and World Vision, to create innovation labs and other activities to respond to humanitarian need. We have trained dozens of aid workers and local partners in Haiti and Nepal in 3D printing skills and printer maintenance. Field Ready has developed learning steps which support different levels of starting skill and knowledge, and a basic training curriculum.

Digital design and manufacturing

3D printing is a way of making three-dimensional solid objects from a digital file. A 3D printer is a machine which automatically converts a coded digital file into a physical item by 'printing' layers of material on top of each other. 3DP has been used in the manufacturing industry for at least two decades, printing materials including metal and ceramic, for prototypes and to test new designs and for final product manufacture. Recently, smaller, more affordable printers have become available. These typically work by melting and depositing plastic filaments and producing small objects, often no more than 25cm in any dimension, with reasonable accuracy. Good examples of objects which can be produced on such printers include plastic spare parts such as clips, models of objects which are hard to visualise or explain (such as the internal parts of a machine), objects which have specific dimensions in order to fit other existing items, or prototypes of items where the shape needs to be felt and seen to be evaluated (such as a handle).

Alongside 3DP, computer aided design (CAD) tools allow digital representations of objects to be understood, modified and tested. Desktop and handheld 3D scanners are used to convert an existing object into a digital representation, which can be reproduced or modified. Scanners vary widely depending on the scale and detail of the object being scanned, from desktop versions to scan small objects to mobile Lidar and camera technology to scan whole buildings or large cultural artefacts such as sculptures. As computer technologies advance all of these systems are improving, becoming faster, cheaper and more capable.

Benefits of 3D printing supplies in the field

Digital manufacturing techniques such as 3DP enable the local production of complex spare parts and the low-volume production of items that are not currently available in the field. This provides the specific items needed, rather than 'pushing' items along the supply network based on supply and not demand. Items may also be modified or adapted to fit local requirements. Printed supplies may be available on site more quickly than if they need to be procured from a remote warehouse or manufacturer. Item packaging for transport can be eliminated and fewer deliveries are needed. Importantly, 3DP filament – the plastic material used by printers – can be recycled and reused.

Local 3DP can also foster community engagement, enabling local people to feel ownership and play a role in designing and improving a range of products and services. This can even have the potential to develop new livelihoods and businesses. The equipment and skills to make relief supplies which we leave in the field will translate to other supplies and items over time.

Making medical supplies in Haiti

Field Ready undertook a trial of 3DP in Haiti starting in 2014, working with a number of partners: Real Hope for Haiti, which operates a health clinic north of Port-au-Prince, Project Medishare, with health activities in Port-au-Prince, and the NGO Haiti Communitere.

Using different 3D printers and software, Field Ready made and tested 165 prints, including prototypes, 21 print failures (where the printing did not finish or went wrong, so that the resulting output was not usable for the intended purpose) and 110 items distributed for use. We printed a unique prototype prosthetic hand (using just five parts), three items to repair and improve the printers, a winged (butterfly) needle holder

(used in collecting blood samples), a prototype screwdriver, three prototype pipe clamps, two prototype bottles and a mockup of a gas cylinder regulator, so that we could accurately test S-hooks used to suspend medical supplies in crowded emergency rooms. This assisted approximately 60 medical patients and a dozen aid workers.

From our research with midwives, we uncovered a supply chain problem involving umbilical cord clamps for new-born babies – simple clips which prevent dangerous infections. The main supply chain for these items comprises volunteers from the United States, who bring them in their backpacks. Most clinics could not secure a supply. When they are available on the market they typically cost $1, and can cost as much as $3. A 3D printed clamp costs just $0.60. Our prints resulted in a reduction in the risk of neo-natal umbilical sepsis, and more efficient (and safer) health worker and patient areas. With the additional items made, we also reduced the likelihood of mosquito-borne disease and enabled a clinic to consider alternative means of providing prosthetic hands for amputee patients.

3D printing spare parts and key items in Kathmandu

Nepal has strong local markets and supply chains. Aid agencies are able to procure most of the supplies they need locally, while good international links enable remaining supplies to be brought in. However, the rapidly changing political context, long delays at border crossings and high customs duties can disrupt these supply chains. These issues were heightened following the earthquake in April 2015. We found significant problems in procuring unusual components (particularly complex components from branded products made in Europe or the United States) as well as some curious omissions from local supply chains, such as plastic fittings used to connect water pipes together. The complex shapes involved in such items means that they are difficult and prohibitively expensive to manufacture using conventional techniques, even by skilled Nepali machinists and craftsmen. Some products available on the market in Nepal do not meet the specifications and standards desired by aid agencies (e.g. buckets with corners where bacteria can grow).

On our first visit to Grande International Hospital in Kathmandu we found much donated equipment, often now broken and disused. This included five baby warmers, three of which had the same fault – the corner clips which hold together the sides of the warming cot had broken. Attempts had been made to repair these using duct tape, and by painstakingly making metal brackets, which turned out to be unsafe. The corner pieces were a custom part, and the baby warmers were old equipment for which spares could no longer be purchased. A Field Ready engineer designed a new corner (aiming for greater strength in the area that had been breaking in the originals), printed and tested it, and then redesigned it. On a subsequent visit, Ajeev Bar Singh Thapa, head engineer at the hospital, said that the new corner fitted better than the original, and looked better too. We were able to print sufficient supplies to repair all the baby warmers.

A lack of proper pipe fittings was identified as a key issue by logisticians and water and sanitation (WASH) teams at Oxfam and Save the Children in Kathmandu. Field Ready visited Barhabise IDP camp in Sindhupalchowk district and identified a clear need for plastic water pipe fittings. We found ‘improvised’ connections using pushed-together pipes, inappropriate metal fittings and bicycle tyre inner tubes, which were often loose and leaky. A few hours later, a design for a fitting to connect two pipes was drawn and then printed in the camp on a portable 3D printer running off a car battery. The pipe fitting, which cost about $0.40 to print, was used to connect pipes that supply water to 18 households (about 75 people). On a

return visit, the fitting was still in place and working well, with no leaking and no degradation of the plastic material. Gunjan Gautam, a local WASH coordinator, often sends engineers into remote areas for month-long visits to install and repair water infrastructure, where it is difficult to check on status later on. He is now keen for Field Ready to go along on a trip to evaluate the potential of 3D printing on site.

Opportunities and challenges for local manufacturing of humanitarian supplies

There are still both human and technical challenges to overcome if 3DP and related technologies are to be more widely used in our sector. Issues such as interoperability between brands and types of 3DP equipment and consumables, and the ease of field work with them (including resistance to dust, intermittent internet connections and ease of repair) must be considered.

Aid workers have little awareness of local manufacturing for humanitarian purposes, and there are few resources for them to tap into. There is no handbook or manual, and no catalogue of 3D printable parts to provide inspiring ideas. There are similar learning needs in affected communities, who may also benefit from an entrepreneurial design mindset (for instance, the ability to recognise whether and how a problem could be solved). We are creating a system of training, and are seeking to partner with organisations that can help with the creation and delivery of training materials. By working with international NGOs and other relief organisations, undertaking projects to validate the technology and remove obstacles to adoption and sharing our work through their networks, we can help aid workers see how 3DP could fit with and assist their work.

Some tasks, such as modifying 3D designs, require a high level of expertise and a significant amount of training. For these, Field Ready is supporting a global online community of volunteer experts called ‘Humanitarian Makers’,+ who can assist remotely with challenging design and testing activities. We have carried out a first test of this from Kathmandu, and received interesting and useful responses online.

Our multi-disciplinary approach involves methods, both humanitarian and technical expertise, human-centered design and capacity-building. This allows new types of problem solving and reworks the logistical supply chain, enabling the provision of surge capacity, specialised products and on-site production in extremely remote places immediately after a disaster, when normal supply chains have not been established.

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