HUMANITARIAN INNOVATION FUND

Final Report

- Please try not to exceed 5 pages (Arial, 12pts) excluding attachments –

Organisation Name	Field Ready

Project Title	Rapid manufacturing for quick onset disasters
Problem Addressed / Thematic Focus	Invention/Service: Humanitarian supply chains improved via 3D Printing
Location	California and Haiti
Start Date	29 Sept 2014
Duration	Three months
Total Funding Requested	GBP 20,000

Partner(s)	Formally named in the proposal included: MamaBaby Haiti (www.mamababyhaiti.org), TiKay Haiti (www.tikayhaiti.org), and Haiti Communitere (www.haiti.communitere.org). In addition, the following partners were engaged: MediShare, Real Hope for Haiti, Griffith University
Total Funding	GBP 28,200

Innovation Stage	Invention
Type of Innovation	Service
Project Impact Summary	Health in post-disaster relief settings

Reporting Period	**Sept-Dec 2014**
Total Spent	**GBP 23,452**

ACTIVITIES CARRIED OUT

Describe all the activities carried out.

Following our plan outlined in the proposal, we carried out the following six main activities:

Preparation: At the end of September, we began preparation involving a number of administrative, logistical, technological and relationship steps. This included procurement and testing of 3D printers and related equipment. We determined that some equipment would donated in-kind while others would be purchased. The printers were tested and packed at our workspace in Mt. View/Moffett Field, California. At this stage, we printed model pieces but the main printing was done on-the-ground in Haiti. We also took care of basic logistical arrangements such as arranging flight tickets, accommodation and on-the-ground transportation. During this stage we undertook background briefings. Over the course of the project period, we repeated these steps for each of the three trips undertaken (in October, November and December 2014).

Partnership building: During the proposal phase of this project, we were in discussion with three partners: Haiti Communitere, Ti-Kay and MamaBaby Haiti. We also were in contact with the local group known as iLab Haiti (an unincorporated start-up). We continued these conversations and then, once in Haiti, we met with these partners and new ones identified during project implementation. This is discussed further below in this report.

Problem Identification: This was a key activity we engaged in. Our approach entails both having solutions that can be quickly implemented as well as being open to new issues and working with others to clarify what those may be. We talked to a host of people in Haiti to verify an array of problems which stem from a lack of immediate medical supplies and other issues such as poorly designed mosquito nets and the need for inexpensive prosthetic limbs.

Training: Under this project, we planned to develop and refine basic training materials and train local aid workers in printing and related processes. In order to do this effectively, we developed a "four-level training framework" (see attached) and exceeding our training goal.

Manufacturing: Using two types of FDM 3D printers, MakerBot Replicators and UP Minis, we made a wide range of items in Haiti. We planned to print 130 items (50 IV bag clamps, 30 oxygen splitters and 50 umbilical cord clamps) but significantly exceeded this amount and experimented with a number of additional items (described in the next section).

M&E: Throughout the project, we carried out monitoring, evaluation and learning. This was captured in several documents (including an "M&E checklist" attached) but, importantly, it was also done informally within the Field Ready team as well as several partners including Griffith University. This includes the design iteration that we took

several of our printed products through (e.g. the umbilical cord clamp with Real Hope for Haiti).

ACHIEVEMENTS

Describe all the results achieved through the activities indicated above and indicate if the project achieved the objective set out.

This project achieved its objectives and went a step beyond each of the specific terms set at the proposal stage. Most importantly, we were able to demonstrate that 3DP is a viable technology that can be applied to humanitarian response. We say this while acknowledging that a number of steps need further testing, refinement and replication. Some of these are detailed in our "lessons learned and idea log" submitted with this final report.

In qualitative terms, we helped beneficiaries with the products we printed and distributed. They included TB patients, newly born babies and aid workers (by providing mosquito-net closures, tool holders and hooks as well as training). This resulted in, for example, a reduction in the risk of neo-natal umbilical sepsis, and more efficient (and safer) health worker work spaces 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 (which, if used, will result in a significant increase in patient mobility and wellbeing).

In quantitative terms, we made and tested a range of medical disposables and other printed items. This included a total of 165 prints including prototypes, 21 print failures and 110 items distributed for use (a "Distribution" list is included with this report). I printed 14 mosquito net clips. We also printed a prototype prosthetic hand (5 parts), three items to repair/improve the printers (filament guides), butterfly needle holder, a prototype screwdriver, three prototype pipe clamps, two prototype bottles and a mock-up of the gas cylinder regulator, so that we could accurately test S-hooks. This assisted approximately 60 medical patients and a dozen aid workers.

Training was another way aid workers were engaged so that the skills and knowledge of 3DP could be effectively passed on. During the project, Field Ready developed a framework for capacity-building and a basic training curriculum that was delivered this twice and trained 16 people in the process. The training included using basic CAD software and two types of printers (UP Mini and MakerBot Replicator). The training was geared for aid workers based in Haiti and took place at Haiti Communitere's conference room in Port-au-Prince.

METHODOLOGY

Describe how the methodology used was or wasn't appropriate to carry out the activities or achieve the objectives set out.

Printing objects that were useful in hospitals was only part of the work; the objects needed to be designed, and designed carefully. This takes skill and a lot of time. We employed effective methods and techniques to achieve our objectives. During initial assessments, we engaged people in human-centred design, rapid prototyping and co-creation through extended participation. Once each printed prototype was made, final users were shown the results and an iterative process was followed until they were sure that the final product suited their needs. For example, a simple umbilical cord clamp went through a prototyping process with changes such as a wider grip, more flexible body and a re-worked locking mechanism (the first design could be opened with a person's fingers, the second with another device such as a knife and the final version, preferred by the recipient, could not be opened once closed).

In this pilot project, three field trips were made to Haiti to learn from the approach we are developing. Several Haitians (belonging to the group iLab Haiti) were employed on a daily rate basis to carry out a variety of tasks including helping with printing. We also provided them with mentoring and coaching on various aspects of our approach.

The approach we have developed involves making and testing print designs closely with the people who will use them, as it is fairly unconventional to have such short development cycles and get such rich feedback. For some of the items, we spoke to nurses at a hospital three times in one week showing them different designs each time. Following this "lean" process reduced the risk that we invested too much in an inappropriate design or solve an unimportant problem (i.e. 'fail fast'). We have also quickly transitioned from demonstrators/first prototypes to higher volume 'field trials' – and by using the same manufacturing method for both, we have reduced the time and risk. This also allowed us to examine interoperability between brands and types (e.g. different sorts of filament) showing that the right arrangements are important for effective operations.

MAJOR OBSTACLES

Describe all the obstacles faced during the implementation of the project and how they affected the planned activities and results.
Indicate what steps have been taken to address these obstacles.
Indicate whether amendments to the planned activities and objectives have been made.

We encountered a number of obstacles which for us translated into a number of "lessons learned" (see attached). For the purposes of this report, these are grouped together into several areas.

Basic working environment: Although there are more difficult places to operate, Haiti does have its fair share of challenges such as power outages, dust and humidity. At least one volunteer found the situation there harsh and so careful management and pre-deployment vetting and briefing was instituted. For the machines themselves, some basic steps taken at the operator/user level were undertaken including ensure that generator times coincided with print times and reducing drafts during printing by enclosing the open-design MakerBot machines with simple cardboard cut-outs. In doing

so, we maintained a high printing success rate. Future field deployments would greatly benefit from a more stable power source, to maximise production times.

Technology: As commercial machines become more sophisticated, their suitability for the "field" often reduces. In terms of software, the maker of one of our printers used in Haiti (MakerBot) recently updated their operating programme and made it "cloud-based" which then required a constant Internet connection. This in turn meant that a workaround off-line solution was needed because of the poor connectivity in Haiti. In the future, all systems need to operate both online and off-line to avoid such problems. We also investigated alternative power sources. We found that consumer level portable UPS systems cannot supply energy to a 3D printer for long enough to continue printing during the transfer from mains power to a generator at the frequency it typically occurs in Haiti. A robust system of batteries and solar panels are needed as alternatives for when power mains are not functioning.

Partnerships: Of the several partners identified in the project proposal, we were not able to work with two to the full extent we originally planned. The first identified partner, TiKay Haiti, works with TB/HIV patients and while we were able to visit their activities in November, they temporarily suspended activities which made follow-up in December impossible. Another partner, MamaBaby Haiti, bases its activities in Cap Haitien and it was ultimately deemed too distant for this project. In their place, we were able to identify two new partners (Real Hope for Haiti, which operates a health clinic north of Port-au-Prince, and Project Medishare with activities in Port-au-Prince) and with a number of others (including Haiti Communitere) to complete project objectives successfully.

Local capacity: The local staff we were with belonged to an informal, unincorporated group known as iLab Haiti. They were already capable of basic 3DP (Level #1) but had challenges with problem identification, design thinking, action plan follow through and quality checking. This meant that more time was needed to achieve basic tasks. We remain committed to transfer of knowledge and technical capacity, which takes appropriate and specifically tailored materials (as well as time to deliver). We feel strongly that it is not enough to simply donate machines with the hope that the rest "takes care of itself." There are few resources for them to tap into (apart from technical materials and those produced by the "maker community") and virtually nothing tailored to the needs of humanitarian response. In short, we found that having a well-developed system of training – which we have now started and are seeking additional support to bring to the field – is essential.

Lack of resources: There were two obstacles here. The first was financial resources. While HIF has been generous in awarding the grant, almost all aspects were implemented using volunteer labour which made management and follow-through an occasional challenge including keeping people in the field for extended periods of time. Second, our short timeline meant that tasks that take longer amount of time (such as design optimisation and mentoring) were not possible. That said, this was designed to be a pilot project meant to test and confirm the applicability of 3DP for humanitarian response; which it did. In our second proposed project to HIF, we have extended the time expected in proposal to account for this challenge.

BENEFICIARIES/HUMANITARIAN INTERVENTIONS IMPACTED

Indicate the beneficiaries as well as the humanitarian interventions that have benefited from the project.

Field Ready engaged beneficiaries throughout this project. As detailed in our project proposal, beneficiaries consisted of two groups: 1) health staff and those who work on programming and logistics, and 2) those benefiting from health care including mothers and newborns, and TB and HIV/AIDS patients. Specifically, we directly assisted three organisations with 3D printing needs: Real Hope for Haiti, MediShare and Haiti Communitere. For instance, the health clinic run by Real Hope for Haiti supports approximately 40-50 newborns each month and we provided 40 clamps. According to Lori Moise, Clinical Director of the Real Hope for Haiti project in Cazale, said "*I think 3D printing will really help in rural areas like ours. It's a really neat technology…and Field Ready has been a neat opportunity*". Similarly, the Medishare clinic in Port-au-Prince was provided a number of nebulisers/tube connectors, umbilical cord clamps and IV bag books benefiting approximately 20 patients there.

PARTNERSHIPS AND COLLABORATION

Describe the partnership arrangements and how these may have changed during the course of the project.

Our project relied heavily on the effective partnerships we formed and nurtured. We engaged a number of other organisations for both technical support and while on-the-ground. Because of the cutting-edge nature of our approach, we found many more groups than those mentioned who were ready to help; since others saw the outputs of our printing. Haiti Communitere provided a venue for other organisations to interact in Port-au-Prince and many aid groups commented that our approach is needed (we now have more work requests than we can fulfil at this time!). We addressed above the challenges we encountered and how we managed them, but overall our experience of implementing this project was overwhelmingly positive and our partners are expecting more from us.

DISSEMINATION

Indicate the steps taken to disseminate project findings/outputs to outside stakeholders.

We planned and implemented an extensive communications dissemination plan. This included six different steps. First, we engaged a range of groups on the group and online including through training announcements, explaining our actions in social media and networking. Second, maintained our website and wrote blogs (including those requested by HIF) such a planned story on ReliefWeb.int. Third, we have had two publications written during the project period about this work (both forthcoming, one with UNESCO

and one with UNOCHA) and have agreed to work with Peter Tatham at Griffith University to collaborate on writing an academically oriented paper. Forth, we attended a number of conferences where we present our work highlighting our HIF-funded project including the Red Cross Global Dialogue on Emerging Technology, the World Innovation Summit and the UN's World Humanitarian Policy Forum. Fifth, we documented our December trip to Haiti in video which will be shared on our website and YouTube (and with HIF). Finally, we have had several traditional news stories written about our work appearing in Al Jazeera and Vice.com as well as a couple forthcoming websites including Core77 and the Huffington Post.

TRANSFERABILITY

Please indicate if there is any potential to replicate the project and how.

Absolutely! The need to improve humanitarian logistics is clear and well documented. Our project has shown that our approach makes a decided impact on this by moving manufacturing to the point of use; it has put the theory into practice. This can be readily achieved in other current and future emergencies provided that the lessons learned are addressed and the methods used are appropriate. A significant part of this is to share our knowledge broadly through a diversity of opportunities. If Field Ready were to transfer and scale this innovation, we expect the following impacts: 1) survivors of humanitarian disasters will get critical lifesaving supplies when, where, and how they are most needed, 2) humanitarian supply chains will ensure the most efficient and cost effective distribution of humanitarian supplies, 3) disaster rehabilitation will be expedited and more cost efficient, and 4) communities devastated by disasters will be empowered (with knowledge, skills, and equipment) for economic growth and resilience.

Report Attachments:

- Four-level training framework
- M&E Checklist
- Lessons learned and idea log
- Product distribution list
- Training attendance sheet
- Additional photos