HOW DO YOU ENVISION USING SUPPORT FROM THE AMPLIFY PROGRAM?

The main challenge we face is one of human-centered design. The Amplify Program would have a tremendous impact on our initiative by helping us address several social design questions we have and by helping us test the hypotheses we have developed.

Equal Access

Based on our survey of 255 refugees, multiple focus group discussions and expert interviews, there will be an extraordinary demand for this facility. How do we regulate access fairly? How do we ensure certain tribes and other social groups do not feel marginalized and left with unequal access? How do we build an open-access facility in a way that ensures equality of opportunity to use it and to benefit from it?

Community Ownership

Furthermore, how do we build **ownership** within the community for this lab? How do we minimize theft and curtail improper uses of the facility? How do we minimize the chances that people break the machines, requiring expensive maintenance and replacement of equipment?

Trade Adjustment Assistance

While 99% of our survey respondents want this lab, some did voice concern in our focus group discussions that the lab would disrupt the economy of the camp. For instance, if someone uses the lab to repair personal items rather than paying for this repair at one of the 3,000 shops in the camp, will we reduce income for some micro-entrepreneurs in the camp? How do we minimize unintended economic consequences? Can we create a mechanism to swiftly and fairly deal with such concerns?

We can't ignore these questions. The only way to succeed in this effort is to take a humble approach and admit what we don't know. We believe we can solve these issues, but only by being totally open about the possibilities of things going wrong. The biggest question, in our opinion, is how can we *not* try innovative and more sustainable approaches to humanitarian relief ? How can we not take advantage of the next industrial revolution and the greatest economic transformation the world has ever seen (see McKinsey article,[1] General Electric research[2] and Wharton Professor Jeremy Rifkin's latest book[3])?

Hypotheses on addressing major social design issues

a) **Undergo extensive community engagement and communication:** We've started this process with two months of intensive social design research in the camp, led by a Jordanian professor of Conflict Studies (Ph.D. in sociology/anthropology). This process of listening,

[1] http://www.mckinsey.com/insights/strategy/The_four_global_forces_breaking_all_the_trends?cid=other-eml-alt-mgi-mck-oth-1504
[2] http://files.gecompany.com/gereports/image/FutureOfWork_8am.pdf
[3] http://www.amazon.com/Zero-Marginal-Cost-Society-Collaborative/dp/1137278463

learning and adapting will be ongoing, led by a full-time Senior Community Manager. We will have several channels for private, confidential communication between the community and our staff to continuously absorb and address concerns that are raised. We will also organize monthly focus group discussions, particularly in the beginning. Formal channels are important, but we have found it even more productive, at times, to just sit and have coffee and shisha in people's shops/homes and to build trust through informal conversation and introductions from friends who are refugees in the camp.

b) **Identify a representative set of well-respected community champions to work in the lab and participate in its governance structure:** Our research identified a number people in the community with extensive training and expertise in electronics, carpentry, blacksmithing, etc. Using existing social structures and networks in the camp, we will recruit community champions to help us build the facility from the beginning.
c) **Fail fast, iterate and improve:** We plan to have a "soft launch" period during which we will work with our community champions to build both the physical and the soft infrastructure of the lab. This will include testing the machines and the operations of the facility by building the furniture for the lab, as well as our open-source vehicle. In general, the first 12-18 months should be viewed as a pilot period, during which we constantly examine and refine our operating model, in accordance with a full monitoring and evaluation plan. We believe the full services of the lab should be built up and implemented gradually during this time.
d) **Consider several trade adjustment measures:** Social and economic development interventions rarely benefit 100% of the population. If our activities reduce the incomes of some micro-entrepreneurs displaced by the incomes created and services provided, we should target them to participate in the lab and benefit from its offerings. For instance, several shops repair bikes in the camp, and some refugees may take their bikes to the lab to repair them instead of paying these shops. We can train these repair shops to upgrade their skills and possibly to offer higher value-added services. Can we offer them space at the facility to conduct their business there as well? Would it make sense to explore a small-scale trade adjustment fund to smooth out incomes during skill transition periods? In the beginning, the benefits of the lab will probably be very concentrated (on those trained and empowered) and the disadvantages rather diffuse, given the size of the lab relative to the size of the camp and the scale of existing commerce. Nevertheless, this is something we need to monitor and consider carefully.
e) **Co-develop and implement full security measures with the Jordanian authorities:** We have already drafted and shared a security strategy with the government and are circulating it. Moreover, we identified several security measures recommended by refugees during our research phase. First, refugees requested the lab to be located away from tents and caravans because they are concerned about the risk of fire. The camp has had several fires, and this risk is top of mind. Second, locate the lab close to health clinics. Our research found at least one refugee lost a finger in a work accident, and there have been a high level of injuries in blacksmithing and carpentry practiced in the camp. This will be less of a risk in our facility, since safety is the very first concern addressed through training, safety procedures, the layout of the lab, skilled supervision and choice of machinery. Third, some refugees suggested we locate the facility close to a police station, which makes sense if we can manage to do so.

HOW ARE YOU THINKING ABOUT SUSTAINABILITY?

Sustainability can mean many different things to many people, so let's address three types of sustainability that come to mind: financial, operational and environmental.

Financial

There are two levels of financial sustainability in question: 1) macro-level financial sustainability of the humanitarian system writ large and how we deal with the economic consequences of conflict; and 2) the financial sustainability of our facility.

In terms of macro-level financial sustainability, our departure point is the following. First, in the words of UN High Commissioner for Refugees António Guterres, "With the exponential increase in needs we have seen just in the last three years, the humanitarian financing system is nearly bankrupt."[4] We desperately need innovative approaches to reducing the suffering of victims of conflict. Second, the average lifespan of a refugee camp is purportedly 20 years, and the average stay is 12 years. While our team has yet to see a solid statistical analysis demonstrating these facts, they are certainly directionally correct. In the MENA region, in particular, there is no end in sight for the raging conflicts ripping us apart. The humanitarian financing system is thus bankrupt and things are only getting worse – much worse. Third, conflict and forced migration are causing dramatically negative consequences on the economies of conflict-affected areas and the achievement of the Millennium Development Goals within them. Conflict accounts for half of all child deaths in poor countries, 1/3 of children failing to complete primary school and 1/3 of people lacking access to clean water. In terms of Syrian refugees, approximately 80% of the children who fled to Lebanon do not attend school and more than half of those in Jordan are out of the formal education system.[5] Conflict and forced migration also exacerbate unemployment, and youth unemployment already reaches 30% in countries like Jordan. According to Her Majesty Queen Rania, there is a widespread opinion (correct, in our view) that youth unemployment in the Arab world represents a "ticking time bomb."[6] Poverty and unemployment fuel the fires of extremism and further conflict, and the reduction in educational attainment due to conflict will only increase poverty and unemployment. Finally, technological progress is rapidly eroding job opportunities for low-skilled workers with low educational attainment. For instance, researchers at Oxford predict that *nearly 50%* of the jobs in the U.S. are at high risk to automation – i.e., replaced by robots and computers – *in the next 10-20 years*. These include jobs in transportation, logistics, administrative support, manufacturing, services, sales and construction.[7] If we find it hard to create jobs now, how are we going to do it in the future?

The situation doesn't look good, and we better find more efficient and effective means of picking up the pieces when things fall apart. We are very concerned about the lack of financial sustainability of the humanitarian system and the inability of host countries to absorb the shocks that result from conflict and forced migration.

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[4] http://www.unhcr.org/542abbc16.html
[5] http://www.huffingtonpost.com/2014/09/18/syrian-children-missing-school_n_5844380.html
[6] http://www.queenrania.jo/media/interviews/english-translation-her-majesty-queen-ranias-interview-al-arabiya-network-part-1
[7] http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

Since the humanitarian financing system is headed toward bankruptcy, the first thing we should do is to identify the biggest cost drivers. According to research cited by OCHA in a forthcoming paper on humanitarian supply chains, logistics account for 60-80% of the cost of humanitarian relief, amounting to $10 billion to $15 billion per year. To reduce these costs, we propose using additive manufacturing (3D printing) and distributed manufacturing – both of which are considered top 10 emerging technologies of 2015 by the World Economic Forum's Meta-Council on Emerging Technologies.[8] Per the World Economic Forum:[9]

> In essence, the idea of distributed manufacturing is to replace as much of the material supply chain as possible with digital information. To manufacture a chair, for example, rather than sourcing wood and fabricating it into chairs in a central factory, digital plans for cutting the parts of a chair can be distributed to local manufacturing hubs using computerized cutting tools known as CNC routers. Parts can then be assembled by the consumer or by local fabrication workshops that can turn them into finished products. One company already using this model is the US furniture company AtFAB.
>
> Current uses of distributed manufacturing rely heavily on the DIY "maker movement", in which enthusiasts use their own local 3D printers and make products out of local materials. There are elements of open-source thinking here, in that consumers can customize products to their own needs and preferences. Instead of being centrally driven, the creative design element can be more crowdsourced; products may take on an evolutionary character as more people get involved in visualizing and producing them.
>
> Distributed manufacturing is expected to enable a more efficient use of resources, with less wasted capacity in centralized factories. It also lowers the barriers to market entry by reducing the amount of capital required to build the first prototypes and products. Importantly, it should reduce the overall environmental impact of manufacturing: digital information is shipped over the web rather than physical products over roads or rails, or on ships; and raw materials are sourced locally, further reducing the amount of energy required for transportation.

Distributed manufacturing reduces the logistics costs of humanitarian relief by allowing us to produce locally, dramatically reduce lead times, reduce inventory costs, avoid mismatches between demand and supply, and mitigate complications with customs offices. Rather than constantly ship in basic goods for refugees, we believe we should start micro-factories like our proposed facility that provide refugees with the tools, training, raw materials and access to open-source communities that enable local production. This solution also trains refugees on the skills of the future, and it simultaneously provides us with fun and engaging ways to provide STEAM education to children. This is how we are thinking about financial sustainability on a systemic level.

Now, in terms of the financial sustainability of our facility, let's consider both the costs and the revenue sides. On the cost side, there are at least three major levers. First, we are training refugees and host communities on how to operate such facilities. This reduces the enormous costs of bringing in expats. In Jordan, for instance, each expat costs the UNHCR $250,000 per year! Why not train the people we are trying to help, reduce costs, mitigate idleness/unemployment, enhance agency/autonomy and decrease dependency on foreign aid? Second, we can realize incredible cost savings by leveraging open-source designs that are crowd-sourced and shared for free on the internet. We reduce the number of staff members it takes to run such a facility by tapping into the

[8] http://www.forbes.com/sites/louiscolumbus/2015/03/09/top-ten-emerging-technologies-for-2015-include-3d-printing-distributed-manufacturing/3/
[9] https://agenda.weforum.org/2015/03/emerging-tech-2015-distributed-manufacturing/

global community of innovators, makers and educators who can offer assistance remotely by co-developing designs with refugees and sharing them over the internet – all the while enhancing training and education for our beneficiaries. Third, we have found tremendous interest from corporate sponsors to donate goods and services that reduce the costs of setting up such facilities. For instance, Ultimaker is donating thirteen 3D printers, a telecommunications company is donating the wifi for the lab, and a logistics company is covering the costs of shipping in the machines.

On the revenue side, we envision several potential streams of income. First, refugees can create 3D designs and products that are sold over the internet on marketplaces like Etsy and Shapeways. Exporting designs, rather than physical goods, is ideal due to the complications and costs of logistics. While the regulations in Jordan currently proscribe such a business model for Syrian refugees, the regulations in other places like Kurdistan are completely amenable to this approach. In such places, the facility can take a commission on sales and effectively act as an incubator for refugee business creation. It could also offer micro-finance to facilitate the growth of such ventures. Second, the facility can act as an incubator and rapid prototyping center for international companies developing humanitarian technology. For instance, we have been asked for help from a German company that has a portable medical diagnostic tool that can rapidly test for myriad diseases using lab-on-a-chip technology. They want to develop their solution for the humanitarian market, and could rapidly prototype this development at our facility. Third, the facility can fulfill contracts from NGOs/donors to make/repair products in the camp, such as battered school desks and water/sanitation devices.

Operational

From Day 1, we have been working hard to ensure that our initiative will be operationally sustainable over the long-term – at least a decade or more. This requires building ownership within the host community, including the Royal Hashemite Court, Jordanian companies and NGOs, local educational and vocational institutes, local entrepreneurs and Jordanian youth. The lead implementing partner in the MENA region for the ROW consortium is 3Dmena Social Innovation, a Jordanian non-profit organization. Fab Lab Barcelona, which leads the global Fab Academy, has already agreed to make Amman a training hub for the MENA region in a Fab Lab planned in the King Hussein Business Park in Amman. Furthermore, we have already launched 3Dmena Academy – sponsored by USAID, Zain, Oasis500 and others – to teach 3D modeling skills, particularly to Jordanian youth. For areas requiring deep, sector-specific expertise, our approach is to train leading local institutions to carry forward the work over the long term. We are thus training the Royal Medical Services, which has the largest prosthetics clinic in the country, on 3D modeling and 3D printing. We have also lent a 3D printer and materials to them, and we are helping launch His Majesty King Abdullah's National Prosthetics Center, which will conduct advanced R&D on prosthetics innovation to benefit both Jordanians and victims of conflict from across the Middle East.

Environmental

Our initiative has a very positive impact on the environment as well. As mentioned above, distributed manufacturing reduces the carbon footprint of humanitarian goods by decreasing the need to ship and transport items to often-remote areas. Moreover, we intend to use the facility to produce and use environmentally friendly technologies, such as machines that enable you to

produce 3D printer filament from recycled materials. We are also exploring a home-based food production system featuring 3D-printable components, the designs for which are posted online for free. The system grows food without soil or electricity and uses 95% less water than conventional agriculture (Jordan is the 4th most water-deprived country in the world). There are even devices like small-scale, 3D-printed wind turbines that are being developed by the open-source community. Solar is a more intuitive renewable energy approach in a place like Za'atari, but this could be different in other contexts. For our lab, we are hoping to find a sponsor who can help us power the facility primarily by solar power.

HOW DOES YOUR IDEA EXPAND LEARNING OPPORTUNITIES FOR REFUGEES?

A Fab Lab is a community education center, the idea for which came out of the Center for Bits & Atoms (CBA) at the Massachusetts Institute of Technology. The global Fab Lab network of 450 labs is facilitated by the Fab Foundation, run out of the CBA.

The Fab Lab will expand learning opportunities for adults by offering training on the use of all machines and supporting software, including 3D modeling, 3D printing, 3D scanning, CNC routers, laser cutters, milling machines, vinyl cutters, electronics design, industrial sewing, digital embroidery, metalworking, woodworking, textiles, painting and more. The co-working space we are building will foster informal knowledge exchange within the refugee community, as well as between refugees and members of the global Fab Lab community and other international experts. Finally, we are allocating budget for several refugees to attend the Fab Academy, which is a 5-month intensive program on advanced digital fabrication.

The Fab Lab will expand learning opportunities for children through its separate day care center that will allow kids to learn by building and making fun, cool, physical and interactive objects. For example:

- Our Director of R&D and Training published this Instructables piece on creating wall-avoiding robots with ultrasonic sensors.[10] Building the robot teaches kids how to use a 3D printer, laser cutter and Arduino.
- Autodesk's Project Ignite offers ready-to-teach open-source projects on 3D design, the Internet of Things, and other emerging technologies.[11]
- Electroninks has a set of open-source electronic modules with which you can create circuits using their roller ball pen that writes with non-toxic conductive silver ink.[12]
- naturebytes has designed a wildlife camera with a 3D-printed, waterproof casing and a Raspberry Pi camera and infrared sensor.[13]
- Google developed Coder, a free and open-source project that enables educators to teach basic web programming skills using a Raspberry Pi.[14]
- Kano offers a kit with which kids can build an educational computer themselves with a Raspberry Pi at its core. Wired magazine writes, "Many have tried and failed to develop a

[10] http://www.instructables.com/id/Arduino-wall-avoiding-robot-FabLab-NerveCentre/
[11] https://projectignite.autodesk.com/app/browse/?pageTitle=Projects
[12] http://www.electroninks.com/resources/
[13] http://naturebytes.org/
[14] https://googlecreativelab.github.io/coder/

wining educational computer for kids. Kano cracks that nut, and does so in a genius fashion."[15]

- littleBits makes an easy-to-use set of electronics building blocks that allows kids to make millions of types of "inventions" and to learn about the world around them.[16]

Beyond these direct educational benefits, we expect more children will be able to attend school if we successfully increase the incomes and self-sufficiency of their parents, as some kids are sent to work in order to support the family.

HOW MIGHT A REFUGEE USE A FAB LAB TO IMPROVE THEIR VOCATIONAL OPPORTUNITIES? HOW WILL WHAT THEY PRODUCE FIND A MARKET?

A Fab Lab epitomizes hands-on, informal training. The Syrian people are known to be extremely good with their hands, and more than 3,000 shops have sprung up in Za'atari -- many providing services such as carpentry, tailoring, blacksmithing, electronics repair, etc. We are providing tools and training that improve their ability to earn a living, and substantially reducing the risk of work-related injuries. The equipment used by refugees in the camp today are often makeshift tools that are very dangerous to operate, like circular saws connected to tables and converted into table saws. The need for more and better tools was heavily emphasized by focus group participants, one of whom said, "There are many tools in the camp. But these are primitive. We started from scratch here. It is all handmade primitive tools that refugees made to manage their needs and daily lives. Now the camp is developing, and we can make more tools as we need in the facility."

The Fab Lab will teach introductory, intermediate and advanced courses on the use of a full range of digital and conventional tools, as described above. Our Director of R&D and Training is a Fab Academy Guru (instructor), and partnering with the global Fab Lab network and NextFab allows us to implement and scale up our course offerings very quickly. We will also iteratively tailor our courses to meet the needs of the community.

In terms of improving vocational opportunities, there are three levels of impact. First, many refugees are desperate for something to do, to reduce idleness and to mitigate depression. Second, refugees interviewed during our research emphasized the benefit the lab will have in enhancing self-sufficiency, i.e., reducing their cost of living and thus the need to generate income to provide for their basic needs. Third, the lab will support the operation of existing businesses in the camp, enable refugees who cannot afford machines to start micro-enterprises, and improve workplace safety. The following are excerpts of what we heard from refugees in Za'atari during our focus group discussions.

Reducing idleness

Several women stressed the following:

- "The fact that women are working in the camp [more than men] is affecting men psychologically. Women are working and men are staying home. It is a change of roles in the camp. This is harming men psychologically."

[15] http://www.kano.me/
[16] http://littlebits.cc/education

- "If a woman is working, and her husband is not, with this project, the tension will reduce because he will go to the facility and use his skills to make things that we need."
- "For men, the most important benefit is psychological relief. Those who used to work in carpenting or blacksmithing in Syria, for example, can go to this facility and make few things. This will help them a lot psychologically."
- "If the psychological state of men improves, it will enhance the well-being of the whole family."
- "I think the psychological and self-sufficiency benefits are equally important. My brother, for example, has a psychological condition now and is under medication because there is nothing for him to do."

We also heard that idleness among men is a cause of domestic violence. Clearly, we can have a substantial social impact just by giving men an outlet for creative and meaningful work.

Enhancing self-sufficiency

The lab will enable the production of basic household goods

- "I wanted to make covers for the mattresses we sit on. I spent five hours to make one cover by hand and my arm ached for days. But if this facility is there, I can go and use the machines and finish all mattress covers for my house in 2 hours."

The lab will enable refugees to make their own home repairs and improvements

- "If you need to fix something at your caravan, the fee for a skilled person to finish the task is around 60-75JDs. But if you take that item to the FabLab, transport cost will be 4JDs. So instead of paying 60JD for someone to come to your place, you can pay the 4JDs for transport and fix it for free at the Lab."
- "The other day our door handle got broken. My husband knew how to fix it, but he does not have the tools needed. So we had to pay for a new handle. But if the FabLab was there, he could have taken the door handle and fixed it there himself and we would have saved the money for something else."
- "We will benefit from it. If you have sections for blacksmithing and carpenting it will be good. Now we have caravans so we can make windows and doors. Life is developing in the camp. So instead of going to a carpenter to make shelves, my husband can come and cut the wood and make us shelves. Everyman knows how to cut wood. It will be better than us paying 10JDs for it. This is a good service."

Even those who cannot or will not take courses to learn the machines will benefit

- "I don't have the financial ability to pay a tailor to make me a dress. But my sister knows how to sew; so I can give her a piece of fabric and she can come to the facility and make my dress. This will be a great help that you will offer to people."
- "I don't know any vocational skill; but when I need something I will ask a friend or neighbour to come and make it for me at the facility. It will be good for that person too because he will make what I need with new and safe machines. So he will also learn something about a new or different machine."

Income

The lab will increase incomes by backstopping existing businesses

- "My brother is a tailor and in his shop he has primitive sewing machines. But if a small piece in a machine breaks down, his whole work is on hold for a week or two. But if he can make use of the Fab Lab to make do till his machine is fixed, then this is a great service."

Access to machines and reliable electricity will allow refugees to make products they can sell

- "It [the Fab Lab] will open chances for me. My husband is in Syria and I cannot afford to buy a sewing machine. So if I have customers like my neighbours then I can come to the facility and make items and benefit financially."
- "I believe those who will come and use the facility to make things to sell will be higher in number compared to those who will come to meet their own needs."
- "The facility will remain very important because most of us do not have sewing machines. And even if we have electricity, we will still need the machines. The fact that the Fab Lab will provide both is extremely important for us."

The lab will provide safer work conditions

- "A tailor who is using a manual machine can also benefit from the facility because the manual machine is harming her health."

In Za'atari, there is a thriving marketplace of 3,000 shops where people sell their products. While selling products outside of the camp is prohibited, this is not the case in other contexts. In Kurdistan, refugees can sell products to the external market. They can also use the skill enhancement offered by such a facility to seek employment. Of course, this could displace employment of the host community and raise social tensions, which is why we emphasize providing opportunities to host communities as well. Finally, in contexts such as Kurdistan, refugees could be trained to sell their 3D designs and products online through multiple e-commerce marketplaces.

WHAT ARE SOME OF THE MAIN ADAPTATIONS YOU HAVE HAD TO MAKE TO FAB LABS IN ORDER TO BE APPLICABLE TO THE REFUGEE CONTEXT?

First, the refugee context poses unique social and political challenges, as well as issues of long-term sustainability/continuity. It's absolutely critical that Fab Labs in a refugee context address these issues from the beginning, by respecting the regulations and concerns of the host government and by finding ways to contribute to training, education, employment and economic growth of the host community (described above and in the "How we are different" document).

Second, to conform with cultural norms in this particular context, we need to have separate operating hours, separate days or separate facilities for men and women.

Third, given the remoteness of many refugee camps, one needs to consider building new infrastructure to house the lab, including a building, power generation and internet connectivity.

Fourth, while Jordan is secure, other contexts may not be, and this requires additional time and capital to develop a full security plan, including an evacuation plan. Security and remoteness also contribute to our emphasis on developing digitally fabricated open-source hardware with international experts, so they can support refugees from anywhere in the world over the internet.

Fifth, our vision is to focus on products that solve basic needs, services that increase incomes so refugees can cover their cost of living, and moonshot innovation projects to address the horrific consequences of conflict. The long-term goal is a Google X for the humanitarian sector: a network of makerspaces in conflict zones in which refugees and open-source communities co-create the impossible. We are now drafting an agreement with a Jordanian company to sponsor open challenges to this effect.

A few ideas for moonshot challenges that we have include:

- Design a low-cost system for monitoring/reporting chlorine barrel bomb attacks in Syria, implemented perhaps with the Nobel Peace Prize-nominated White Helmets. We are thinking of a combination of Arduino-based environmental (soil) testing, plus lab-on-a-chip technology for blood/urine tests, plus an Ushahidi-type solution to instantly map crowdsourced information on confirmed attacks.
- Working with Uplift Aero, develop UAVs for humanitarian relief that drop specific supplies to a specific person in a specific location at a specific time. These UAVs have been developed, and they can drop 1kg within a 50km range (25km there and 25km back). However, we are considering a particular context that might require additional technical modifications and improvements. The dream outcome would be to alleviate outbreaks of diseases by dropping medicine into a conflict zone with active sieges/blockades that are preventing relief from reaching civilians.
- Develop a series of UAVs that can map out the location of unexploded ordinance, anti-tank mines and anti-personnel mines. Most likely, this would entail one UAV that can identity the mines with a high degree of probability, another that can verify the existence of the mine, and perhaps another that can detonate the mine.

More immediately feasible challenges could include:

- Design of a motorized, low-cost personal transportation device, especially designed for female refugees in the Middle East. In Za'atari, women cannot ride bicycles for cultural reasons, and the 18 sq km is extremely difficult to traverse in the extreme heat. Moreover, some of the women are injured from the war and yet are forced to walk. The device should be open-source and made of locally available materials. We should be able to build it in the Fab Lab in Za'atari and it should be repairable by the many shops in the camp. This could be as simple as four large wheels, a platform to stand on and a pole to hold / control the motor. It would be ideal for the device to be able to carry a small amount of cargo and even 1-2 children. Of course, it needs to be as affordable as possible.
- Design an open-source vehicle for transporting up to 12 passengers and/or cargo around refugee camps in the Middle East. Tuk-tuks used in Kurdistan are only $1,500. We would envision this solution to be similar but with a wider bed in the back with removable benches. We should be

able to make the vehicle in the Fab Lab with the right components. Ideally, it would include recycled/refurbished/remanufactured components, and it would be excellent if it were electric.

- Design a swarm of open-source, auto-follow UAVs that hover above rescue workers and triangulate the locations of survivors of disasters and attacks against civilians in war (e.g., with infrared cameras/sensors).
- Design an Arduino-based fire detection system operationalized over a wireless mesh network using internet of things communication protocols. The system would warn surrounding tents and caravans of fires and save lives. The solution would be open-source and also very applicable in some of the world's largest slums. The mesh network should be utilized for additional purposes as well, but this could begin to demonstrate the possibilities of a Smart Refugee Camp.
- Develop a small workshop in the lab to make 3D printer filament out of recycled materials, such as plastic bottles and ABS parts from old vehicles.
- Develop an open-source hack for Ultimaker 3D printers to make them suitable for use in conflict zones in the Middle East, e.g., protection from dust, environmental control, printing while moving, etc. Much of this exists already, but we can customize the design parameters to make the outcome maximally suitable for desert environments and conflict zones.
- Customize this mini-farm grow box with 3D printed components for use in refugee camps to enable individual families to grow vegetables they want, while reducing the environmental impact of growing / transporting food. In particular, customization would include ensuring that the box is designed to grow vegetables actually desired and eaten by the population in question.
- Design an easily assembled / disassembled open-source shelter for refugees in the Middle East. It should be (at least partially) digitally fabricated on site, cost <$2,000 in materials, last > 3 years (with maintenance), be easily repairable/maintained, and suitable for the environmental conditions in the region. Ideally, the shelter would be raised above the ground and contain both living quarters and a shower, toilette and small kitchen. It should also be customizable by the individual families to suit cultural needs, and it should be modular (easy to expand). The large consortium that created the Refugee Housing Unit (RHU) spent $7 million and 4 years on R&D to complete a prototype before moving to production. It then spent another $7 million to set up a production line. Replacing pre-fab options that can be dropped for immediate humanitarian relief such as this one would probably not be the goal of this solution, but the RHU lasts for 1.5 years without maintenance and 3 years with maintenance. Perhaps there are alternative options we could develop that complement the RHU. It’s imperative to see if leveraging the open-source community and the expertise of digital fabrication-focused architecture schools like IAAC in Barcelona would reduce the time and cost of R&D.

"I'D RECOMMEND CHECKING OUT THIS TWO PROGRAMS THAT USE HUMBLE APPROACHES TO CHANGING THE LIVES OF THEIR COMMUNITIES. IT IS VERY ALLURING TO DROP STATE OF THE ART TECHNOLOGY INTO A UNDERSERVED COMMUNITY, BUT WITHOUT THE NECESSARY INTRODUCTION, THE POTENTIAL CAN BE MORE DISTRIBUTIVE THAN BENEFICIAL. / / THERE MAYBE LEARNINGS TO APPLY FROM THIS PROGRAM OF HOW TO INTRODUCE NEW TECHNOLOGIES AND EDUCATION INTO A COMMUNITY / HTTP://WWW.HOLE-IN-THE-WALL.COM/BEGINNINGS.HTML / / ALSO, THE BAREFOOT COLLEGE, SPECIFIC

TARGETS GRANDMOTHERS IN VILLAGES TO ENSURE THE EDUCATION AND TRAINING STAYS IN THE COMMUNITY AND DOESN'T FLEE TO THE NEARBY CITIES. THEY ALSO ASK THE WHOLE COMMUNITY TO SELECT THE INDIVIDUAL WHO WILL ATTEND AS WELL ASK HAVE THE COMMUNITY PAY FOR THE TRAINING AND THEREFORE ACCESS TO ELECTRICITY. THIS SET UP ENSURE THE COMMUNITY IS INVOLVED AND HAS A STAKE IN THE SUCCESS OF THE PROGRAM. / HTTP://WWW.BAREFOOTCOLLEGE.ORG/WOMEN-BAREFOOT-SOLAR-ENGINEERS-A-COMMUNITY-SOLUTION/"

Thank you very much for sharing these examples! My background is in technology for development, so I'm familiar with these great initiatives. The principles of learning by doing, community ownership and providing technology-focused vocational training to low-skilled populations all resonate with us very strongly. We hope that after answering the above questions, this approach to our work is more clearly articulated, but if not, please let us know!

Thank you again for all of these great questions and for the opportunity to elaborate on our initiative.