Project Description and Narrative:

The Need for the Surgical Lamp

Providing unplanned surgical care when necessary is an integral service provided by hospitals in the remote regions of many developing countries. Often due to issues of poverty, ignorance, isolation and lack of transportation, medical treatment and care is largely ignored until surgery becomes a necessity. Given that hospitals are few in number and far apart, especially in remote regions of developing countries, these surgeries are often not planned in advance and hospitals need to be ready to perform surgeries as and when patients get to them. In addition, prevailing conditions of violence, malnutrition and unsafe transportation lead to situations where immediate surgical care becomes required and hospitals are forced to act as "trauma centers". Inadequate surgical lighting in developing countries is a big barrier to the provisions of surgical care by hospitals. Our multidisciplinary team aims to solve three key challenges concerning surgical lighting in the developing world:

- Lack of quality lighting
- Unreliable power grids
- Lack of sustainability for donated lamps.

These challenges pose a threat to healthcare in the developing world and demand a solution that will be sustainable, reliable, and affordable.

Firstly, the **lack of quality surgical lighting** in the developing world makes surgeries tedious and very dangerous. Many clinics in the developing world cannot afford surgical lamps or do not receive donated lamps. Clinics are typically forced to use ambient lighting, handheld flashlights, or oil lanterns for their procedures. These light sources are not bright enough to perform quality surgeries and may be unreliable or dangerous: a single handheld flashlights isn't bright enough and doesn't provide the stable lighting of a surgical lamp; oil lanterns tend to be dirty, dangerous to operate and provide very low quality light; ambient lighting is rarely bright enough for surgical settings and is inefficient due to its diffuse nature. Our surgical lamp will provide hospitals an affordable and safe solution for high-quality surgical lighting.

Secondly, there will be problems providing power for the light even if hospitals have high quality surgical lighting due to the **unreliable electrical power grids** in developing countries. Power loss ranges from 30 minute brownouts several times a week in major Filipino cities to month long blackouts in rural Uganda. Even if a clinic is lucky enough to have a surgical lamp donated from a developed country, it becomes useless when the grid goes out and the doctors have to resort to handheld flashlights [1]. Donated surgical lamps don't normally have built-in battery backups since they are coming from developing nations, which depend on a reliable electric grid. Many clinics have external batteries or backup generators, but the halogen bulbs used in these lamps draw a significant amount of power that may be needed for other necessary machines and equipment in the hospital. Also, most hospitals cannot afford the fuel to power the generators. Doctors have had to beg power stations to provide uninterrupted power to hospitals during complicated surgeries, often to no avail. In this scenario, most doctors don't even try to finish the surgery; they just try to close the patient up before he dies [1]. Providing a reliably

powered surgical lamp gives surgeons the option to finish the surgery in the event of a power outage and therefore can save lives.

Thirdly, the **model of developed countries donating surgical lamps is unsustainable**. All these lamps require custom made replacement parts even for simple parts like the light bulb, rendering most donated lamps unusable even after just a short time. These parts are expensive to buy and ship and might not even be made anymore due to the age of the device [1]. Clinics in developing countries frequently have an "equipment graveyard" full of donated equipment that are unusable because of parts that cannot be fixed. Purchasing additional lamps is often cost-prohibitive for hospitals, as new surgical lamps range from $2,000 to $8,000. Furthermore, continued reliance on external donations prevents these hospitals and clinics from becoming sustainable entities that can fully participate in the local economy.

It is clear that the healthcare sector in the developing world needs a surgical lighting solution that solves its critical needs for quality lighting, grid insensitivity, low price, and sustainability.

Solution

The M-HEAL Surgical Lamp Team is a subset of the University of Michigan multidisciplinary student group Health Engineered for All Lives (M-HEAL) and is devoted to developing a solution to the above problems in a reliable, affordable, and sustainable way. We intend to and are fully committed to making a surgical lamp that will vastly improve healthcare in the developing world. The E-Team grant will allow us to further develop our surgical lamp and carry out additional prototype testing in the developing world. The grant will enable our team to tackle all three problems of surgical lighting in the developing world by the methods described below.

Firstly, the proposed lamp solves the problem of power outages during surgery. Our proposed surgical lamp can charge either from the grid or with a human-powered crank. It then seamlessly switches to battery power in the event of electrical grid failure. This will allow the surgeons to continue surgery with adequate lighting even during power failure.

Secondly, the proposed lamp addresses the issue of sustainability: these lamps are designed for local assembly and maintenance by using parts that are readily available such as car and bicycle parts and LED lamps which are becoming common in sub-Saharan Africa. We intend to not only design the prototype, but to also develop a well thought-out user manual and video tutorial. We will hold sessions at our field sites to instruct local engineers and entrepreneurs how to build and maintain the lamp. This approach provides for easy access to replacement parts, stimulates the local economy by creating jobs for local machinists and entrepreneurs, and reduces cost through lower shipping expenses (local shipping instead of international shipping from developed countries). A list of major lamp parts and evidence of their availability in the developing world is provided in the table below:

Bicycles	Bikes provide the metal frame for the lamp and are available across the developing world in either junkyards or scrap metal retailers (both common in the developing world)
LEDs	The prototype testing in Uganda and a subsequent study of

	developing countries showed that LEDs bulbs are readily available in our target markets [1]. The bulbs are typically shipped to the developing world in inexpensive flashlights from China because they did not meet specific luminosity requirements for their original purpose. Research also shows LEDs are increasing in the developing world due to their low cost and efficiency, meaning they are readily available to assemble our lamp locally.
Motorcycle batteries	Motorcycles and scooters are a popular mode of motor transportation in many developing countries, and junkyards have many motor batteries lying around that can be used to power our surgical lamp.

Thirdly, the proposed surgical lamp aims to dramatically reduce the costs of lighting. The lamps are also inexpensive: M-HEAL manufactured an alpha prototype for only $200, while a comparable lamp from the developed world is approximately $2,000 [2]. During our initial field test in Fort Portal, Uganda last summer local technicians were able to build fully functional versions of our lamp, using only locally available materials for $40 [1]. This low cost enables the hospitals to purchase the lamps from local retailers and reduces their dependence on donated lamps.

Pictures and blueprints of the current lamp have been uploaded into the appendix section.

Team Description

Our lamp team consists of University of Michigan biomedical engineers (graduate and undergraduate), an applied physicist graduate student, a medical research assistant, and business school (MBA) students. The entire team will be involved in a comprehensive needs assessment. The engineering students will translate the user requirements into technical specifications. The engineering students and physicist will lead the team in concept generation and selection exercises. Following the selection of the final design, the technical team members will build a series of prototypes and validate the lamp's performance. The medical research assistant will collect input and feedback from physicians who have worked in the developing world and will be responsible for making and managing a survey that asks surgeons to evaluate the lamp. His additional duties include publicity, grant writing and establishing hospital contracts across the developing world. Our business students will be responsible for the marketing strategy and distribution of the product. Our international liaison is Saravanan Selvan (one of the MBA students).

Project Team Members:

Dr. Aileen Huang-Saad (Lecturer, BME): PI, Stephen DeWitt (graduate student, applied physics): Design Lead , Mustafa Gulam (medical student): grant writer, medical liaison, Patrick Ingram (graduate student, BME): electrical design, prototype manufacture, Carl McGill (graduate student, BME): design, prototype manufacture, Elliot Hwang (graduate, BME): design, prototype manufacture, Michael Weist (senior, BME): design, prototype manufacture, Phil Guan (graduate, BME): design, prototype manufacture, Michael Harrison

(sophomore, BME): design, prototype manufacture, Saravanan Selvan (MBA student): Business Plan, Kumi Hospital Liaison, Naroo Krishnan (MBA student): business plan, marketing strategist, Anita Bhat (MBA student): business plan.

Project Work Plan

Our design team uses an iterative design process: we make a prototype of the lamp at the University of Michigan, test it in Ann Arbor with a panel of surgeons with experience working in developing countries, and then send students and the lamp over to a partner hospital in the developing world. The students will take detailed notes of the conditions in the country and compile detailed feedback from surgeons, medical technicians, and potential entrepreneurs about the implementation of the lamp. The lamp and the students will then return to the University to improve the design and repeat the process until a lamp is made that meets or exceeds the standard of need in developing countries.

A graphical form of our project outline entitled Grant Timeline is located in the appendix.

Project History and Milestones

Our surgical lamp team has already built an alpha prototype out of new hardware store parts to determine the viability of the surgical lamp in the developing world. This past summer we sent the prototype with Abigail Mechtenberg, a University of Michigan doctoral student doing research in Fort Portal, Uganda, to field test our lamp with the local medical technicians in Fort Portal and have gained valuable feedback for iterative design. We also made contact with local engineers and physicians in Fort Portal, Uganda. The medical technicians at Mountains of the Moon University in Uganda looked at our design, gave suggestions and manufactured a similar lamp to ours for $40.00 using only local parts [1]. Based on their feedback and suggestions we improved the design of our lamp, specifically the horizontal-vertical joint (see the beta-prototype design drawings in appendix). We have since begun work on a gamma-prototype built entirely from LED flashlights, bike parts, and simple electrical components.

Marketing Strategy

Our overall vision is to market the lamp's blueprints and prototype to NGOs, local engineers, micro-lenders, and entrepreneurs (henceforth known as manufacturers) so they can build and improve the design in a cost-effective manner, ultimately selling it within their local community. Each one of these four manufacturers will have different objectives, but while their value propositions may be unique, we believe they will all be compelling.

Our marketing strategy is structured in three phases: 1) market research and networking with NGO partners to find viable manufacturers 2) contract negotiations with entrepreneurs and hospitals, and 3) providing support to local manufacturers selling our product.

Phase 1: We have established concrete partnerships with three NGOs that are established in three markets which could use our product: Kumi Hospital in Uganda, Appropriate

Technologies Collaborative (ATC) in Nicaragua and Unviersity of Michigan's Project Suyana in Peru. Our close relationship with these NGOs is critical to the success of our venture; through these partnership we gain their contacts and experience in their respective markets. We will primarily seek hospitals and entrepreneurs in the area who would be interested in buying and selling our products respectively. We are going to multiple sites to see how the lamp fits in these sites and to determine good sites to sell our lamp. We will use the funds to field test and determine which location(s) has the best market niche for our lamp, at which point our testing and market research will become much more targeted.

Phase 2: Once we have sought out interested parties who are willing to buy and sell our product, we will seek to create an "exchange" for our lamp. We will do this with contract negotiation: we will help the hospital draft a contract establishing the terms of an agreement with the local manufacturer who will then go out and build the number of lamps specified in the contract. This process significantly reduces the start-up risk for the manufacturer.

Phase 3: We will phase out of the contract negotiations and shift to mainly a support entity for the local manufacturer. We will support him with any technical/business issues he has and he will pay us a franchise fee for using our designs and utilizing our support. Most of the fees that they will pay to us are for blueprints and "complimentary assets." One key complementary asset is a video detailing lamp manufacture and assembly. These videos will be targeted to educated entrepreneurs and engineers who can effectively build a lamp.

A marketing schematic in the appendix graphically shows our product's path to sustainability.

The grant money goes to one-time expenses needed to get the program running. Once we enter phase 3, the project should be self-supporting. The marketing strategy graphic in the appendix outlines this process. This distribution channel scheme will allow M-HEAL to drive penetration of its surgical lamp without taking on the production and after-sale service for which it is not equipped. We have 501c (3) non-profit status through the Department of Biomedical Engineering and are primarily concerned with creating economically sustainable solution that, in the long term, does not require our attention on the day-to-day level. The lamp has garnered very positive and wide publicity including mentions by The Discovery Channel blog, local newspapers, Detroit Public Radio, and national websites.

We will work with the University of Michigan Office of Technology Transfer to develop a plan of intellectual property protection and licensing scheme. Once we have an established market position, we may start licensing to individual entrepreneurs and engineers in the developing countries.

References

[1] Mechtenberg, Abigail Reid. Understanding the Importance of an Energy Crisis. PhD thesis, University of Michigan, 2009.

[2] Surgical Lamp: Ritter 355-022 Model. http://www.ariamedical.com/midrit-355-022.html.