Engineering World Health January Institute
2019 Cambodia
Final Report

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Executive Summary

The 2019 Engineering World Health January Institute in Cambodia was a great success this year. This program, run in partnership with the University of New South Wales in Australia, hosted 35 participants from 4 different countries.

During the first month of the program, the participants underwent intensive language (Khmer), cultural, and technical training conducted at the University of Puthisastra in Phnom Penh. The technical training includes both lab and lecture, with occasional hospital visits to familiarize the participants with Cambodian hospital settings before they travel to their second month placements. Also during the first month, the group went on an excursion to Toul Sleng Genocide Memorial Museum and to the genocide memorial park at Choeung Ek to better understand some of the recent history of Cambodia.

After their training, participants are transported to one of our partner hospitals, located throughout Cambodia, where they work alongside hospital staff in groups of 2 or 3 to repair equipment, assess the needs of the hospital, and complete a secondary project to provide for one of these needs. During their 4-week placement, participants were placed in 14 hospitals throughout Cambodia and **collectively repaired 303 pieces of equipment, worth approximately US $606,000[1], and completed 21 secondary projects.**

Equipment ranged in complexity from autoclaves to blood pressure cuffs. Notable repairs include a group that repaired their hospital's only centrifuge (the only way to diagnose certain diseases, such as malaria) and repairing a dental chair that had been out of use for over a year. Many students expressed an increase in their technical experience and confidence as a result of their work in the hospitals.

The participant feedback was generally very positive, with good notes on areas of improvement for the program, both for before the participants arrive in Cambodia and for their time in-country.

We are grateful to all who helped make this program not only possible, but a success in the eyes of our participants and our partners in Cambodia.

Medical Equipment Repair

The 35 participants repaired or completed preventative maintenance on **303 pieces** of medical and hospital equipment, totaling approximately USD $606,000[1] of equipment repair service. Their work is summarized in the following charts:

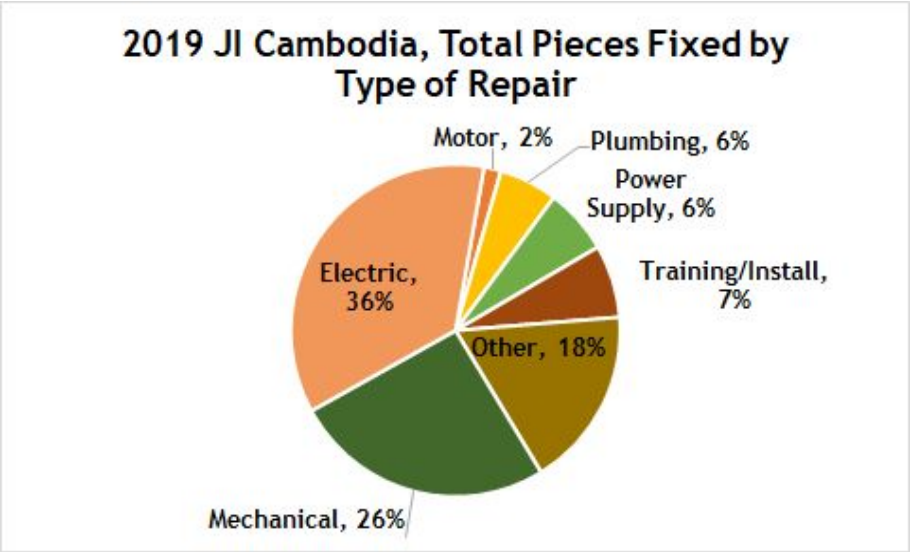
Repairs/Maintenance by Type of Equipment

Type of Equipment	Total Pieces	Type of Equipment	Total Pieces
Air Compressor	1	Nebulizer	4
Anesthesia Machine	2	Ophthalmoscope	2
Aspirator/Suction Machine	28	Oven, Lab	2
Autoclave	14	Oxygen Concentrator	15
Blood Bank Refrigerator	2	Patient Monitor	32
Blood Pressure Device, Automatic	6	Phototherapy	3
Blood Pressure Device, Manual	6	Pulse Oximeter	3
Centrifuge (electric or hand operated)	9	Scale (laboratory and in wards)	7
Computer	2	Shaker Machine	5
Dental Drilling Machine	2	Stethoscope	2
Distiller	1	Thermometers	3
ECG	2	Transformer	1
Electrosurgery Machine*	4	Ultrasound machine (imaging)	7
Fetal Stethoscope	11	UPS (various)	6
Furniture	2	Vaccine Refrigerator	1
Incubator (infant)	6	Ventilator	2
Infant Warmer (Radiant or other)	4	X-Ray Film View Box	1
Lamp, examination	7	X-Ray Machine*	3
Lamp, surgical	25	Other	66
Microscope	4		

*User training and/or low voltage and peripherals repairs only

Repairs by Hospital and Type of Repair

Hospital	Items Touched	Repaired	Abandoned	Repair Percentage
Hospital 1	39	33	6	85%
Hospital 2	27	18	9	67%
Hospital 3	31	27	4	87%
Hospital 4	22	12	10	55%
Hospital 5	26	21	5	81%
Hospital 6	51	32	19	63%
Hospital 7	21	17	4	81%
Hospital 8	19	10	9	53%
Hospital 9	39	27	12	69%
Hospital 10	44	30	14	68%
Hospital 11	40	29	11	73%
Hospital 12	22	12	10	55%
Hospital 13	25	11	14	44%
Hospital 14	35	24	11	69%
Total	**441**	**303**	**138**	**69% avg**



Secondary Projects

Each team is encouraged to complete a secondary project for their hospital during their placement. Through interviews with hospital staff, the participants identify a need in the hospital and find a creative way to meet that need.

Hospital 1

This group's project was to build a water distillation unit, based on the recommendation of previous years' groups and the hospital needs report. The water distillation unit was intended for the use of autoclaves only, as the hospital's autoclaves previously used bottled water or water from air conditioners. As this water was not distilled, heavy mineral deposits were left in the autoclaves. The water distillation unit was assembled but not finished and connected to the autoclave, due to difficulty finding parts and limited time. This project is recommended to be continued by future students.

Distiller

Hospital 2

The aim of this group's secondary project was to illuminate an area of the hospital that was particularly dark at night. This area was next to the side entrance to the hospital and it had two bathrooms, a communal clothesline, a carpark, several food and drink vendors and a source of clean drinking water. These facilities are shown in the images below.

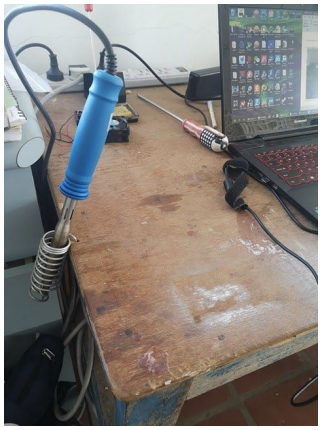

Considering how many facilities and resources are present, a significant amount of people are often wandering around this area, both during the day and night. The lack of light sources increased the risk of injury, as well as generally making individual's jobs and activities more difficult at night. Furthermore, the road on the other side of the hospital's outer wall was also poorly lit. This was a hazard to the motorists, pedestrians and shopkeepers who would be present just outside the hospital. Thus, the students chose to light up the street as well. The street, and vendors occupying it are shown in the images below.


The group was successful in completing the project and both the area within the hospital, as well as the street outside were well-lit as a result. By the end, with the help of the hospital's BMET, they had installed 12 street lights outside of the hospital's walls and 13 on the inside, as shown below.


Hospital 3

For the secondary project, this group renovated and cleaned up the BMET working room. This hospital had had a workshop for the part time BMET, but over time, rubbish and broken equipment built up and turned the workshop into an equipment junk yard. The group organized all the equipment between disposal, rechecking, and repaired units. They also added a soldering station to the workspace.


Before

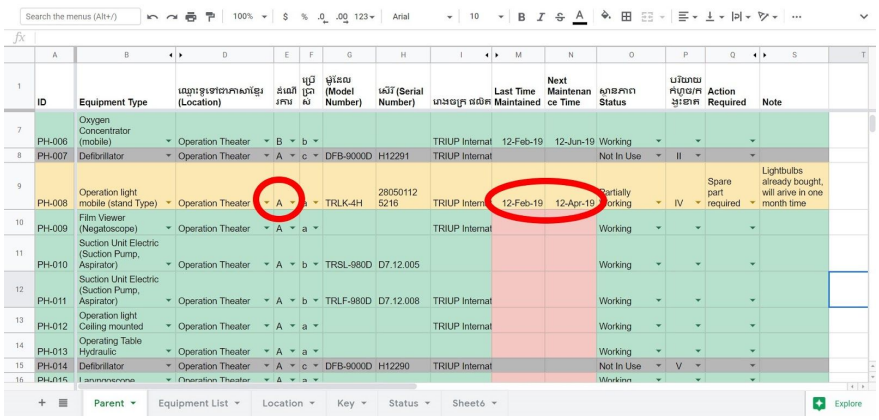
After and Soldering Station

Hospital 4

This group created a new online, automated inventory on Google Sheets for the hospital's BMETs to keep track of all the equipment in the hospital and maintenance times.

The BMETs explained that their existing inventory system was very laborious to update every quarter, as it was Microsoft Excel, meaning that copies of the file would have to be made every time updates were made. Furthermore, the BMETs needed to perform maintenance on the machines every 2, 4, or 6 months depending on the machine, and they had no system to track this.

Here is the system the group created:

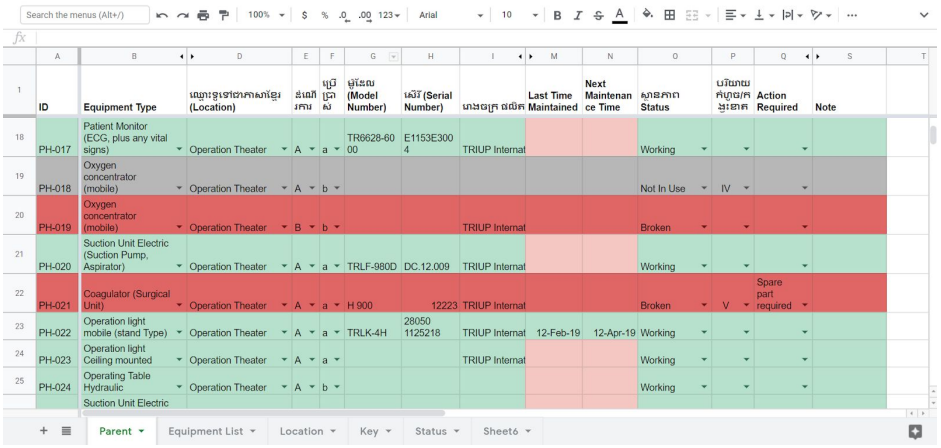


ID	Equipment Type	(Location)	(Model Number)	(Serial Number)	Last Time Maintained	Next Maintenance Time	Status	Action Required	Note
PH-006	Oxygen Concentrator (mobile)	Operation Theater	B b		TRIUP Internat	12-Feb-19	12-Jun-19	Working		
PH-007	Defibrillator	Operation Theater	A c	DFB-9000D	H12291	TRIUP Internat		Not In Use	II	
PH-008	Operation light mobile (stand Type)	Operation Theater	A	TRLK-4H	28050112 5216	TRIUP Intern	12-Feb-19	12-Apr-19	Partially Working	IV	Spare part required	Lightbulbs already bought, will arive in one month time
PH-009	Film Viewer (Negatoscope)	Operation Theater	A a			TRIUP Internat		Working		
PH-010	Suction Unit Electric (Suction Pump, Aspirator)	Operation Theater	A b	TRSL-980D	D7.12.005			Working		
PH-011	Suction Unit Electric (Suction Pump, Aspirator)	Operation Theater	A b	TRLF-980D	D7.12.008	TRIUP Internat		Working		
PH-012	Operation light Ceiling mounted	Operation Theater	A a			TRIUP Internat		Working		
PH-013	Operating Table Hydraulic	Operation Theater	A a					Working		
PH-014	Defibrillator	Operation Theater	A c	DFB-9000D	H12290	TRIUP Internat		Not In Use	V	

When the user inputs the last time maintenance was performed, it auto-generates the next suggested time for maintenance based on the machine's category. A, B and C

correspond to 2, 4 and 6 months respectively. The maintenance boxes change color depending on whether maintenance is overdue or not.

Cells also change color automatically depending on the user's input in the "Status" column. This way, the BMET can easily scan through the inventory to see what needs fixing. There are many drop-down boxes to make it easier for the BMET to record information.



	ID	Equipment Type	(Location)	(Model Number)	(Serial Number)	Last Time Maintained	Next Maintenance Time	Status	Action Required	Note
18	PH-017	Patient Monitor (ECG, plus any vital signs)	Operation Theater	A	a	TR8628-6000	E1153E3004	TRIUP Internat		Working			
19	PH-018	Oxygen concentrator (mobile)	Operation Theater	A	b					Not In Use	IV		
20	PH-019	Oxygen concentrator (mobile)	Operation Theater	B	b			TRIUP Internat		Broken			
21	PH-020	Suction Unit Electric (Suction Pump, Aspirator)	Operation Theater	A	a	TRLF-980D	DC.12.009	TRIUP Internat		Working			
22	PH-021	Coagulator (Surgical Unit)	Operation Theater	A	a	H 900	12223	TRIUP Internat		Broken	V	Spare part required	
23	PH-022	Operation light mobile (stand Type)	Operation Theater	A	a	TRLK-4H	28050 1125218	TRIUP Internat	12-Feb-19	12-Apr-19	Working		
24	PH-023	Operation light Ceiling mounted	Operation Theater	A	a			TRIUP Internat			Working		
25	PH-024	Operating Table Hydraulic	Operation Theater	A	b						Working		
		Suction Unit Electric											

Parent | Equipment List | Location | Key | Status | Sheet6

The sheet also has the functionality to auto-translate the equipment name from English to Khmer after the user chooses the equipment type from a drop down list.

The participants taught the BMET how to use the sheet and hide columns/rows that he did not want to view. He liked this functionality as it decluttered the inventory.

<u>Hospital 5</u>

This group completed 2 secondary projects: cleaning up the storeroom and distributing equipment to doctors, and installing sanitation stations by the bathrooms around the hospital.

This was EWH's first time working in this hospital. Upon arriving, the participants were shown straight to the storage room and found they could not enter the room due to clutter all the way up to the door. The group created a document that detailed all the contents of the storage room, which they then showed to the hospital Director. The Director was able to quickly inform them which of the stored equipment was needed around the hospital. The group then laid out all of the useful donated equipment and invited doctors from around the hospital to come and take whatever was needed. Within an hour almost all of the equipment had been taken. This

included stethoscopes, carts, wash basins, resuscitators, oxygen nose hoses, surgical tools and much more.

Storage Room 1 Before and After

Storage Room 2 Before and After; Doctors picking up equipment

The Director mentioned to the students that hygiene after using the bathroom was a concern within this hospital. The group worked to improve hospital-wide hygiene by installing hand sanitation stations around the hospital, especially at the toilets. They purchased square bottles from Siem Reap and used double sided tape and epoxy to fix them to the bathroom walls. The hospital has further stock to refill these hand sanitizers, making this project sustainable. Posters were placed next to each station as a reminder and instruction to wash hands after using the toilet.

Hospital 6

The hospital staff requested the participants provide a solution so that hand-sanitizers could be easily accessed anywhere around the hospital. Until now, hand-sanitizer bottles were loosely lying around and rarely available when needed or kept in a consistent place. To remedy this, the participants purchased about 50 pencil cases and fixed them on the walls around each department in the hospital, providing a permanent location for the hospital's existing sanitizer bottles.

Installing the stations and the finished product

Hospital 7

This group completed three secondary projects: portable oxygen analyzers, maintenance checklists for hospital equipment, and software for the BMETs to keep track of equipment maintenance history.

The idea for the portable oxygen analyzers to test oxygen concentrators was suggested by the On the Ground Coordinators. To do this, the participants removed a working oxygen analyzer from a unused Millennium M5 oxygen concentrator, then created a circuit to make it possible to run with only a 12v power supply outside a concentrator. The participants tested the analyzer and found it worked perfectly, then trained the BMETs in the hospital how to use it.

The BMETs asked for a maintenance checklist for the hospital equipment to be designed. The participants created maintenance checklist documents for 21 different

types of medical equipment, which can be used for over 150 different pieces of equipment in the hospital. The documents had a simple design and were written in English and Khmer to allow the BMETs to easily understand, then shared with other EWH groups to allow all hospitals access to the maintenance checklist. Overall a great success for maintaining the integrity of the hospital equipment.

Finally, they created a software for the BMETs to better keep track of their equipment maintenance history. The software was created using data from an updated inventory list and allows the BMETs to add or remove existing equipment. Maintenance history of each equipment is linked in the program and organized based on their inventory number. The software can be used on various Operating Systems. Its main requirement is a JAVA runtime environment. The software currently accounts for 440 pieces of equipment and will generate or display each equipment history as requested by the BMETs. The project was completed successfully.

Hospital 8

The hospital director here told the group the hospital was hoping to renovate the kitchen building in coming years. This group's project was to complete some of these renovations for the hospital. They began by washing the exterior walls of the building before painting 2 coats. They then moved on to the interior walls, brushing the dust and spider webs off the walls before painting them as well. The project went very well and the hospital and kitchen staff were very thankful for the help in their renovations.

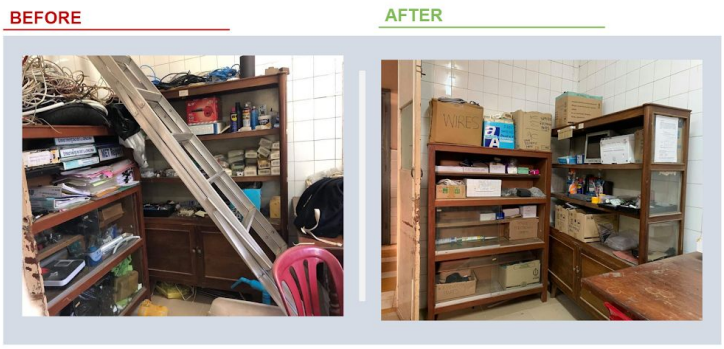
Hospital 9

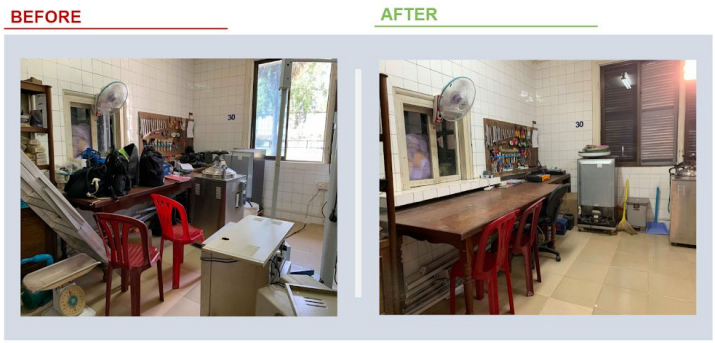
This group's secondary project was creating a user manual for an infant incubator that was new and unused. The pediatrics department had previously been trained on the machine but were still unclear about its functions and so the machine was left untouched. Using the company operation manual as a reference, they created a user guide with instructions in English and Khmer on preparations, cautions, and steps on how to use the incubator. After giving the nurses copies of the guide, the group taught several nurses how to operate the machine in person.

Hospital 10

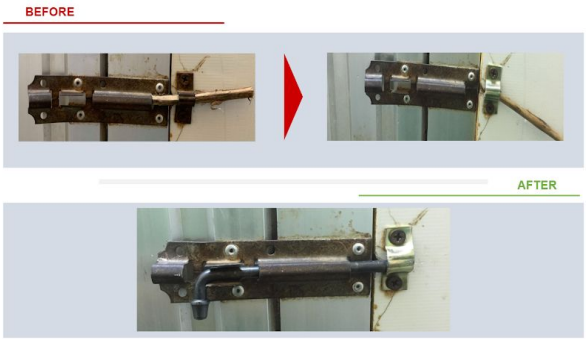
This group completed two secondary projects: cleaning the workshop (including purchasing a lamp for the workshop) and installing locks on the bathroom door. The

workshop was full of unused equipment and spare parts which the participant frequently utilised to test out, replace parts, or fix incoming equipment. The project was successful and was worthwhile as the group found many useful spare parts and made more space for incoming equipment to be fixed.





Installing bathroom locks was selected as an ‘extra,’ as it fit the group’s criteria for being a useful and effective secondary project. The locks on the bathroom which is frequently used by patients and staff were rusted and had no metal bar to securely lock the door whilst it was in use. The group was able to purchase locks from a local market and install them in the bathroom.



Hospital 11

This group had requests to restore a bicycle from its aged condition. To restore the bicycle, they sanded its surfaces, cleaned it, dismantled it, degreased and cleaned the chain, spray-painted the frame, reassembled it and lubricated the chain.

Hospital 12

This group also completed two secondary projects: patching a hole in the concrete floor and creating a base and state for the fusion and syringe pumps.

For the concrete repair, there was one major hole at the center of the room. A few minor holes were also present throughout the workshop and required attention. Previously, the cement was poured on top of a soft sand base and big, sharp rocks, causing instability and cracks, eventually leading to the collapse of the floor.

Workshop assistants were able to provide necessary materials and tools to fill the holes. The group decided on a concrete to sand ratio (no aggregate was available), cleaned the hole, and applied layers of paste. The absence of coarse aggregate in the mix and the depth of the main hole made the team apply layer by layer instead of pouring the entire mix. The hole was covered and leveled with a trowel. Other small holes and cracks were covered and patched with the remaining concrete paste.

While the mix without coarse aggregates concerned the team for the strength of the new concrete floor, it still managed to hold heavy loads on top. It even withstood point loads of a chair with one of the members sitting on it. Overall, it was a satisfying result limited access to concrete tools. All the workshop assistants and supervisor were very pleased.



The participants developed a relationship with the head of the maternity ward in this hospital and asked her what they could build that would be useful. She said that she needed 2 stands for the delivery rooms that could hold two types of fusion/syringe pumps and an IV drip bag. The common IV stands available locally are far too unstable for this purpose.

With the help of workshop assistants the participants purchased two 45cm diameter steel plates. They cleaned the edges with an angle grinder, marked and drilled holes for the wheels, and purchased 2 of the commercial IV drip stands from a local pharmacy. They unscrewed the poles from the base and asked the assistant to weld a large nut onto the bases. The nuts had to be lathed to match the thread of the IV stands. The base plates were then painted and everything was put together.

Hospital 13

This group assisted the blood bank staff in setting up their annual Valentine's Day event, which was the day after the participants finished work at the hospital. This hospital has a very large blood bank that is an asset to the area. The blood bank was expecting a large influx in patients for Valentine's Day and needed extra space to house them. The hospital also used the event as an opportunity to freshen the decal

and do some cleaning. The participants helped set up an outside reception area, putting up chairs and tables and decorating the marquee. They also made and put up signs near the entrance and decorated the interior of the blood bank. At the end of the day, the participants were able to give blood of our own and had the opportunity to see where it all went and what it was used for.

Hospital 14

This group had two secondary projects: grounding the hospital surgery rooms and build an emergency power supply for the hospital.

They noticed that very little of the equipment used in the hospital was grounded, especially the surgery room where no equipment was grounded. Furthermore, all equipment in the surgery room was connected to homemade power boards with unsafe plug heads and exposed wires. A lot of the equipment in the surgery room comes in direct contact with patients, and without the use of a ground line, an electric shock to a patient could be fatal. The group made new power boards with a safe ground wire and ensured that all leads to surgical equipment included a ground wire.

To provide backup power supply for the surgery rooms, the group successfully made and upgraded new patient monitor batteries at a low cost and taught the hospital's BMET how to make new batteries as well as replace, use, and maintain the batteries of UPS for ECU and ECGs in the surgery rooms.

Surgical light with battery packs

Participant Debriefs and Feedback

Engineering World Health seeks not only to assist the hospitals in which our participant volunteers work, but also to influence the volunteers' own development as engineers and as global citizens. Our participant feedback this year was very positive. Some of the words used to describe the program were amazing, eye-opening, challenging, fun, and (frequently seen in our warmer countries) hot. Many student gave very compelling stories when asked about their biggest accomplishment, including learning to change the batteries between two different models of power banks, two instances of participants fixing the hospital's only centrifuge (a device critical for diagnosing diseases), and building a relationship and gaining trust with the doctors in a particular department. The main area of improvement that the participants requested was lowering the cost of the program.

Acknowledgements

The On the Ground Coordinators were Jessica Luff and Will Lewin. The engineering courses were taught by Dr. Larry Fryda. Language and cultural training were provided by the University of Puthisastra. Our partnership with the University of New South Wales is headed by Dr. Lauren Kark. Thank you to all who helped make this program possible.

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[1] EWH estimates the mean value of each repair at USD$2000