**Memo of Transmittal**

4 December 2017

To: Chris Muench

From: Felix Situ and Mark Eden

Subject: Recommendation Report regarding Machine-Controlled Stacklights in Industries

CC: Erin Martin-Elston

Attached is the Recommendation Report regarding publicizing machine-controlled Stacklights in all industries. This report will demonstrate how these lights impact the safety and efficiency of the industrial workplace compared to human-controlled stacklights.

*Production Scenarios:*

1. Fabrication of the housing and assembly of the entire Stacklight at C-Labs
2. Buying all components of Stacklight and assembling them at C-Labs
3. Not producing the Stacklight

*Methods*:

To fully establish an engineer's ethos, it is essential to provide the audience with credible and unbiased sources, such as:

* Interview with Chris Muench
* Interview with Brennan Ruthardt
* “The Challenge of Brownfield Projects: The Chemical Engineer” (Journal Article)
* “Worker Fatigue: Understanding the Risks in the Workplace”  (Journal Article)
* “Labour Protection and Safety in the Brewing Industry: Grain Products & Mixed Fodder” (Journal Article)
* Data from the United States Department of Labor

*Final recommendation*:

My final recommendation is that C-Labs begins production of the machine-controlled Stacklight with outsourced material and in-house assembly. Based off our research, we believe that stacklights hold the solution for modernizing brownfield machine scenarios.

**Recommendation Report**

Machine-Controlled Stacklights Saving Lives in the Industries

Prepared by: Felix Situ and Mark Eden

Prepared for: Chris Muench

Date Submitted: December 4, 2017

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**Introduction:**

For every industrial business, phenomenal logistics and immediate safety alerts are crucial to ensure the safety of its employees and to maximize profit. An effective method to maintain health and safety in a work environment is “to identify … hazardous and harmful factors” (Melnik 2). Fatigued workers are especially prone to incidents due to their “lack of awareness and attention to work surroundings” (Sawatzky 4).To minimize the number of casualties, workers must be warned of a disaster as soon as possible to avoid injury.

Many industrial machines can be described as  “Brownfield Scenarios”. A Brownfield machine (or system of machines) performs isolated discrete functions. An example would be a large multi-million dollar rock sifter that was built before the internet existed. These machines cannot provide adequate safety and productivity notifications on their own. In order for Brownfield machines to be modernized, installation of sensors, computers, cameras, and screens is required. Factory owners worry about updating their machines because:

1. When an Industrial Machine is not functioning, the factory is losing money
2. The risk of damaging the machine is too large
3. The cost of contracting a specialized technician is too large

For owners of these Industrial Scenarios, Brownfield machine modernization is not cost effective and has been proven to be “notoriously difficult to execute effectively” (Leppington 1). This is where the Stacklight comes into play.

Stacklights communicate the status of a machine to employees. As the name suggests, they are composed of different colored cylindric tubes stacked vertically upon one another, with each tube displaying a unique color, similarly to traffic lights.

The Stacklight provides a perfect solution for Brownfield Machine Scenarios because of their non-invasive installation. Installation of a Stacklight only requires access to the power source of the machine, which is used to determine if the machine is running, not running but on, or not running. Obtaining that information with a quick glance (to see the color of the Stacklight) allows employees to monitor machines from a distance, rather than looking at a small screen/gauge. The Stacklight is perfect for Brownfield Machine Scenarios because of their non-invasive installation.

The company C-Labs developed a prototype of their own Stacklight, and this report focuses on solving the problem of if they should move on to production of the Stacklight or not. We have analyzed two different production scenarios, and our research provides a clear answer to the problem.

Production Scenarios:

1. Fabrication of the housing and assembly of the entire Stacklight at C-Labs
2. Buying all components of Stacklight and assembling them at C-Labs
3. Not producing the Stacklight

**METHODS**

In order to make an unbiased, ethical, and informed recommendation, many different methods were employed during the research process. The main source of information about the Stacklight and its development came from an interviews with Brennan Ruthardt, a software and hardware developer, and Chris Muench, the C.E.O. of C-Labs. A plethora of online resources also provided information about Industrial Scenarios, production costs, and material costs.

Interview with Brennan Ruthardt

Interviewing Brennan Ruthardt yielded all of our information about the research and creation of the Stacklight prototype. Brennan leads the Stacklight development team at C-Labs, so his knowledge and opinion about the project is imperative when making our recommendation. We also discussed the benefits and downfalls of in house production and assembly rather than outsourced production and assembly. .Even though Brennan possesses the most knowledge about the Stacklight, it is important to have more than one perspective taken into consideration. A complete list of interview questions can be found in “Appendix A: Interview with Brennan Ruthardt” [1].

Interview with Chris Muench

My interview with Chris Muench provided the bulk of our research regarding business and retail practices that would ensue if C-Labs was to begin production of the Stacklight. Chris provided detailed insight about what companies would purchase and utilize Stacklight. A complete list of interview questions can be found in “Appendix B: Interview with Chris Muench” [2]

Online Resources:

In addition to the interviews, I have used Cal Poly’s databases to gather several peer-reviewed journal articles that analyzes the challenges and safety in dangerous industrial workplaces.

1. “The Challenge of Brownfield Projects: The Chemical Engineer” (Journal Article) by Mark Leppington
   * This article examines the many factors that leads to the dangers of working for a brownfield project, such as outdated documentation, obsolete equipment, and poor managements. With these dangers present, stacklights are essential to increase workers’ safety.
2. “Worker Fatigue: Understanding the Risks in the Workplace” (Journal Article) by Susan Sawatzky
   * This article explores workers’ fatigue in the industrial workplaces and how they easily lose awareness of their surroundings without assistance even during incidents.
3. “Labor Protection and Safety in the Brewing Industry: Grain Products & Mixed   
    Fodder”  (Journal Article) by Irina Melnik
   * This article details the quantification of the level of safety in an industrial workplace, using a brewing industry as case study. One of the safety tasks include the “safety of production equipment” (Melnik 2), in which stacklights provides for their surrounding workers.
4. “Stack Light Engineering Reference Guide” by Onyx Industries Inc.
   * This reference guide serves to inform those in the group unfamiliar with the concept of stacklights. It thoroughly documents its purpose, functions, quality, and other important considerations.
5. “OSHA Data & Statistics.” by the Occupational Safety and Health Administration
   * This website from the United States Department of Labor provided data explaining that death-related industrial incidents occur on an average of thirteen annually. It is our goal to gradually decrease these numbers.

**Production Cost Analysis**

Each individual Stacklight unit breaks down into three main components:

1. The plastic housing
2. The custom PCB circuit board
3. The various light related electronic components

|  |  |  |  |
| --- | --- | --- | --- |
| **Costs of each component in both production scenarios** | | Fabricated and Assembled in House | Outsourced fabrication |
| **Prices** | Housing | $5 | $40 |
| Circuit Board | $35 | $15 |
| Light Components | $15 | $15 |
| **Total Price of 1 Stacklight** | | $55 | $70 |

*(Table 1) This table breaks down the costs of all 3 components of the Stacklight in both production scenarios.*

For C-Labs, we recommend two Stacklight production scenarios. The first one involves 3D printing the housings, building the circuit boards by hand, and installing the lights into the housing’s. The second scenario outsources the fabrication of the housing, outsources the PCB circuit board manufacturing, but does not outsource the light installation.

In-house fabrication presents a lower materials cost per unit compared to the outsourced fabrication, but the imported materials would require a substantially lower assembly time. 3D printing the housing takes a 3D printer about 16 hours to complete. This means the limit of Stacklights created per day is equal to the number of 3D prints that C-Labs possesses. Assembly time of 3D printed Stacklights runs between 2-3 hours per unit, while assembly times of foreign fabricated materials is around 30-45 minutes.

Even though outsourced materials cost more upfront, the amount of time and money saved by having lower assembly time is extremely lucrative in a mass manufacturing setting. If an employee assembles 1000 stacklights, it will take between 2000 to 3000 hours. Even if every housing has been fabricated, it would still take around 250 eight hour work days! If the employee’s pay was $20 an hour, it would cost $40,000 just for labor! With foreign fabricated materials, it would take one employee 125 days to assemble all 1000 units. The cost of this labor is exactly half of what it was with In-house fabricated parts. Also, it would take 125 days less to complete assembly of all 1000 units.

**Conclusion**

At this moment, only humans can use the stacklights to alert others of impending incidents. However, it is problematic to rely solely on them due to their imperfection. C-Labs aimed to improve the use and accessibility of stacklights, that allows machines to become the controller and to communicate with each other without human interactions. This would also allow machines that originally lacked communication abilities to create a network of production. In a factory setting, safe and productive machinery provides an effective and safe labor environment. Whenever an experiment fails, possibly leading to an incident, the machine will flash the Stacklight’s customizable colored lights, grabbing “immediate attention” from its surrounding (Onyx 1). Machines detect material defects during emergencies faster than humans ever could. The company’s new product was already tested and provided logistical and safe solutions in a factory setting.

C-Labs has yet to further continue the production of these stacklights publicly, however, this recommendation report aims to finish what they started. We believe that the possible production of these machine-controlled stacklights would become beneficial and profitable for the company. The United States Department of Justice have recorded approximately 13 industrial-related deaths every day (OSHA), and each incident could potentially cost businesses millions of dollars in lawsuits and factory downtime. The best method to avoid industrial-related deaths is to prepare its workers to evacuate as soon as possible. By allowing machines to immediately alert workers of dangerous situations, yearly industrial deaths will decline dramatically. Proactive management of possible hazards is “recognized as a good business practice” (Sawatzky 1).

**Recommendation**

I recommend that C-Labs finalizes research and begins production of the machine-controlled Stacklight with outsourced material and in-house assembly.

**Appendix A: Interview with Brennan Ruthardt**

The following is a list of question asked during my interview with Brennan Ruthardt

1. What is the stacklight composed of?
2. What material is the housing composed of?
3. What vendor produces the PCB board?
4. Where are the lights and electrical components purchased from?
5. How many hours of man work does it take to build a stacklight?
6. What is the minimum amount of profit that would be accepted per individual sale?
7. How much would you sell each stacklight for?
8. If damaged to the point in which the lights do not work, would it be cheaper to repair it or to purchase a brand-new product?
9. Would you include warranty? If so, how much would it cost?
10. What industrial grade does the stacklight pass?

**Appendix B: Interview with Chris Muench**

The following is a list of question asked during my interview with Chris Muench

1. Where would the stacklight be installed?
2. How does the machine control the stacklight?
3. Who would stacklight be marketed to?
4. How much would each stacklight be sold to?
5. How many hours of man work does it take to build a stacklight?
6. What is the minimum amount of profit that would be accepted per individual sale?
7. How much would you sell each stacklight for?
8. Would you include warranty? If so, how much would it cost?
9. What industrial grade does the stacklight pass?

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