Northern Arizona University- Abel Aldape's Logbook

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Team Meeting 1

Date: 1/28/20 Topic: Team Kickoff 1st Meeting

Location: EGR Rm 107 Attendees: Abel, Trent, Chen, Landon

1. Important Notes:

a) Hangout App will be used for communication
b) Landon elected Team Leader, no rotating role
c) Team Meetings Weekly at 10:15 am
d) Google Drive Created – keep organized and detailed

2. Upcoming Assignments:

a) Set up meeting with client

b) Email:Hesam.Moghaddam@nau.edu
Phone: 928-523-5185
Office: Engineering Building, room 257
Tuesdays 10am-2pm Thursdays 1230-230 pm

c) Questions for Moghaddam
    a. Environment? Impeding Traffic? Cost expectations? Expectations from client? Constraints?

3. Tasks

a) Team Contract- All members
b) Problem Definition- All Members
c) Set Up client meeting – Trent
d) Agenda and Minutes – Abel
e) Submit Team Contract- Landon

Figures: N/A

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Team Meeting 2

Date: 2/4/20 Topic: Project Definition

Location: EGR Rm 107 and Dub Downstairs Attendees: Trent Abel Chen

1. Important Notes

a) Project Definition due Friday (2/07/20)
b) Agenda 2 and Meeting Minutes Friday (2/07/20)
c) Chen began researching potential stakeholders
d) Trent began working on Objectives and Constraints
e) Abel reorganized the google drive and began meeting minutes
f) Informal meeting on Thursday (2/09/20) in the Dub downstairs
g) Finish rough draft by Wednesday (2/08/20) – Need to get TA's signature

2. Assignments and Tasks

a) Project Definition – completed by all members
b) Meeting Minutes and Agenda 2 – Abel Aldape

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Team Meeting 3

Date: 2/11/20 Topic: Team Dynamics and QFD

Location: EGR 107 Attendees: Trent Abel Chen(late)

1. Important Notes:

a) Only Abel and Trent for third consecutive meeting
b) Very little communication in the chat
c) Discussing contacting Pete to make him aware of problems

2. Deliverables

a) QFD due on Monday (2/17/20)
b) Agenda and Meetings
c) Set up Meeting with Client – Trent

3. Work done

a) Began working on the QFD
b) Located in the Google Drive

See below for QFD and Discussions

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Engineering Requirements / Customer Requirements	Importance	Cost	Volume of Vehicle as per not "oversized"	Mass as per not being "oversized vehicle"	Operation Time (10-15 minutes per Sign)	Extension or Reach of Cleaning Apparatus	Material Properties of Extension Apparatus	Collection Efficiency of Used Cleaning Water	Debris/Obstructions Removed from sign	Restore Reflectivity of Sign	HorsePower of Scrubber/Extension Arm	Customer Competitive Assessment: 1 Worst	2	3	4	5 Best
Inexpensive	1	9		3	3		3				3	A		B		C
Portability Down the Roadway	3		9	3		1					1	A		B		C
Time Efficient	3		3		9	3		1			1	B		C		A
One Person Operation	1		3	3		9					3	B		A		C
Reliable/Consistent Operation	3	3		1			9		3	1	1	C		A		B
Cleaning Water Retrieval	3		1		1			9	1	1		C		B		A
Clean Road Sign	9				3		1	1	9	3		C		B		A
Electro Mechanical Device	1	3				1	1				9	C		B		A
Safety (OSHA,ADOT legality)	9	1	1	3			1	3	1			A		B		C

Technical Importance: Absolute		30	51	45	60	22	49	66	102	33	24
Technical Importance: Relative		6%	11%	9%	12%	5%	10%	14%	21%	7%	5%
Target Value		150	115		15	18.5	+	95	95	+	5
USL		180	130		20	37		98	98		10
LSL		60	100		5	5.55		90	85		1
Units		k$	m^3	kg	min.	m		%	%	SPEX	HP
Design Competitive Assessment	Worst: 1	A	A	A	B	B	C	C	C	C	C
	2										
	3	B	B	B	C	C	B	B	A	B	B
	4										
	Best: 5	C	C	C	A	A	A	A	B	A	A
Limiting Factors	ADOT Policy	Regulations									
	No Impeding Traffic	Flux (Cars/min)									
	No Damage to Sign	Force Gauge									
	OSHA Compliant	Regulations									

Discussion of QFD Results: We ranked our highest customer requirements as Clean Road Sign and Safety. This is because the entire objective of our project is to clean the overhead highway signs. The Safety requirement is related to almost all the constraints of the project. The engineering requirements that matter most according to both the technical and relative importance are debris removal, material collection, operation time, and vehicle volume. No major surprises with the QFD.

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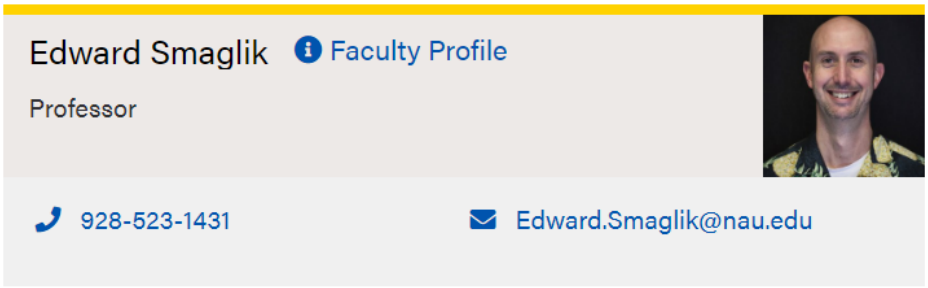
Team Meeting 4

Date: 01/24/20 Topic: Concept Generation

Location: EGR Rm 107 Attendees: Abel and Trent Chen(30 minutes late)

Important Notes:

1) 1. Team Dynamic is struggling
   a) No communication in chat. Tardiness and attendance have been seriously lacking.
   b) Course of action is to communicate with members that peer review points will be lost unless changes are made.
2) Concept Generation
   a) Begin 6-3-5 concept generation
   b) Only two members present so the two papers that were passed around were the cleaning method and deployment method.
   c) Major developments were the combination of fluids and a rotating scrubbing material for the cleaning method
   d) For the deployment method we had a heavy reliance on drones. The team is going to research the legal side of using drones and then continue to develop the concept.
3) New Resource (Professor Smaglik)
   a) Professor Moghaddam recommended we talk to Professor Smaglik who is an industry professional in the transportation. Moghaddam made clear that we needed to be prepared with questions and an agenda to ensure an efficient professional process.



Upcoming Assignments:

1) Preproposal presentation due 3/11/20
   a) All team members begin reviewing presentation rubric
2) Research Abrasive cleaning methods
   a) Abel
3) Research Pressure Washer Dissipation

a) Trent

4) Dry Ice cost analysis
   a) Chen
5) Set up meeting with new client
   a) Trent and Abel

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Team Meeting 5 (Client Meeting with Smaglik)

Date: 3/5/20 Topic: Meeting With Smaglik

Location: EGR Rm 120 Attendees: Trent and Abel Chen(Late)

Important Notes:

1) Met Early to prepare and refresh for meeting with Smaglik
   a) Review concept generations to discuss
   b) Focus of meeting is to discuss scope of project and to clarify constraints
2) Meeting with Professor Smaglik
   a) Inquired about drones- no idea
   b) Inquired about safety regulations and he referred us to a resource- Manual of Traffic Control Devices
   c) Not an abundantly helpful meeting
3) Begin working on Presentation
   a) Formatting and layout first
   b) Be prepared to change presentation as necessary depending on Carson Pete's review of other presentations.

Upcoming Assignments:

1) Presentation due (3/11/20)- All team members
2) Meeting Minutes and Agenda – Abel
3) Log books due (3/13/20)

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Team Meeting 6

Date: 3/10/20 Topic: Presentation

Location: EGR Rm 107 Attendees: All members

Important Notes:

1) Arrived to see the presentation heavily changed and edited, with no sign of a previously saved copy.
2) Landon admitted to the changes saying he felt it's what was needed to match the rubric, and felt the other presentation was subpar. This is made worse by the fact he was not involved with the first draft and missed three weeks of meetings.
3) Reformatting of the entire presentation
    a. New presentation was excessively covered with bad quality pictures
    b. Different Formatting and fonts throughout presentation
4) Landon then proceeded to drop the class due to his attendance grade and probable low peer review scores
5) Meeting before presentation to rehearse because the time slot was used to redraft the entire presentation.

Upcoming Assignments:

1) Appendix and Gantt chart- Chen
2) Finish Presentation- Everyone

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Client Meeting 1

Date: 2/3/20 Client: Professor Moghaddam

Attendees: All Group members

Questions/Purpose of meeting:

1. Introduce team members and build client relationship
2. Understand Problem
3. Define Objectives and Constraints

Important notes from meeting:

1. Important conclusions are summarized in the problem definition table.
   a. Unique client the customer needs he gave us were easily transitioned into engineering requirements.

Priority	Objectives	Engineering Requirements
1	Reliable ^	stress analysis
2	Retrieval of fluids^	percentage of used material and recovered material
3	Clean Road Sign ^	Readable from 500 ft
4	Portability *	miles per hour, ft
5	Time Efficient ^	seconds (s)
6	Easily Operable *	1 person
7	Cost *	Dollars ($)
8	Electro Mechanical *	power (joules)
	Constraints	**Engineering Requirements**
	Regulations	as recommended by OSHA
	No stopping traffic	Traffic flux (Cars/s)
	No damage to signs	Force (N)
	Safety	Factor of Safety

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Client Meeting 2

Date: 2/23/20 Client: Professor Moghaddam

Attendees: All team members

Questions/Purpose of meeting:

1. Major Purpose of meeting is to define the scope of the project
2. Need to determine if emphasis should be on cleaning apparatus or deployment method
3. Want to be able to deliver a reasonable level of work at the end of the project and need to determine exactly what is going to be engineered.

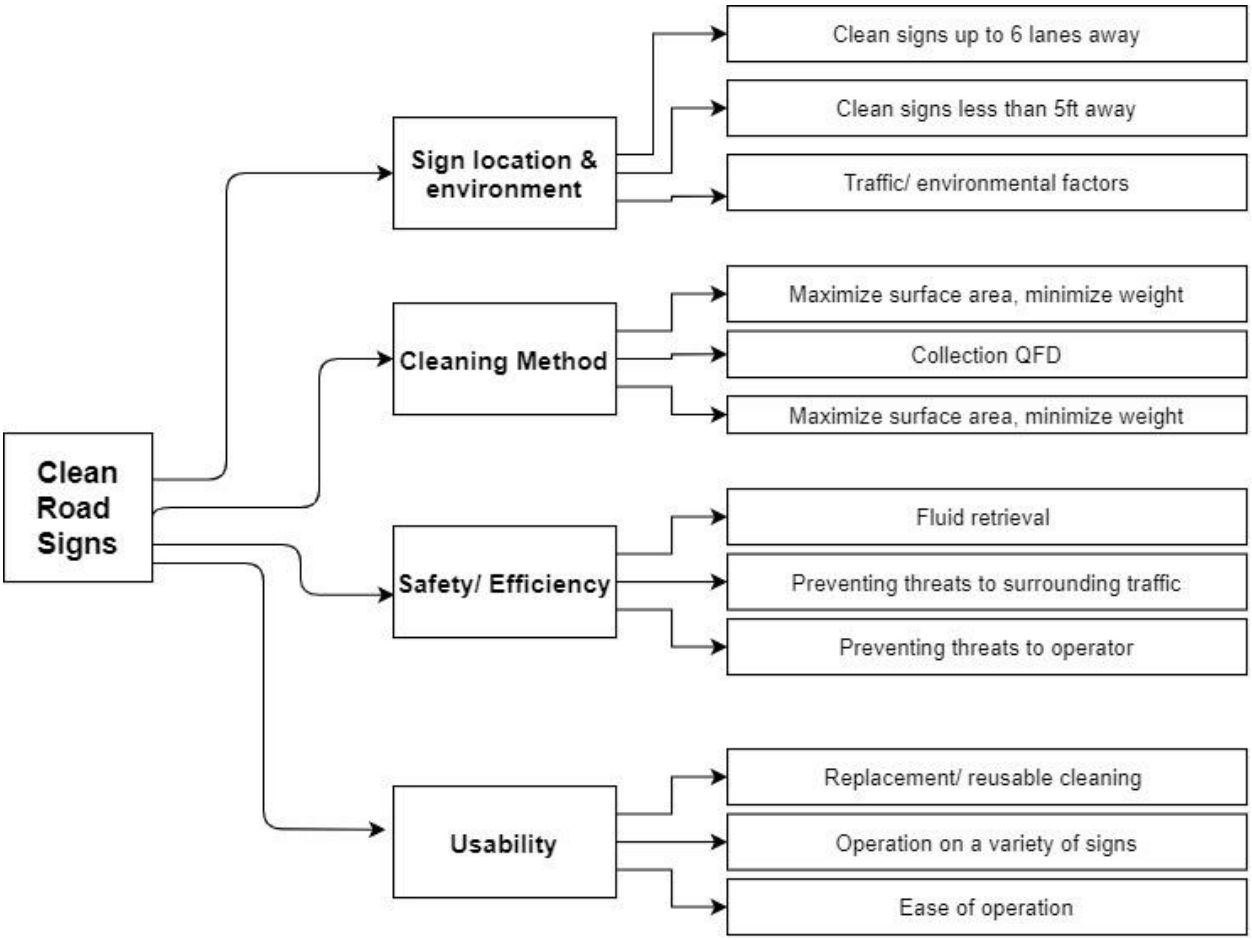
Important notes from meeting:

1. The major take away from the meeting was that Professor Moghaddam wants a realistic project proposal, so if we develop a super cool cleaning device but has no way to get to the sign its useless.

Conclusions:

1. This means that we must have a proposed deployment method as well as a proposed cleaning method. In order to maintain a manageable amount of work, the group has decided to research an effective deployment method but focus a majority of our engineering efforts on the cleaning method itself.

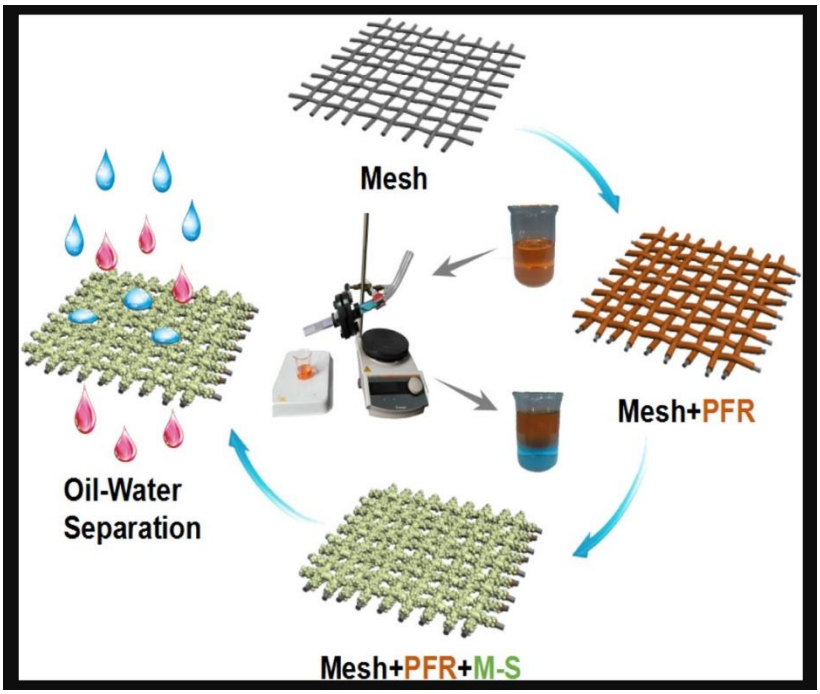
Problem Decomposition



1) Problem was reduced into the four areas seen here
   a) Sign Location and Environment- Trent
   b) Cleaning Method- Abel
   c) Usability- Chen
   d) Safety/Efficiency- Landon

SOTA Review

1. Peer Reviewed Article on Superhydrophobic material



- Superhydrophobic refers to the contact angle between the water droplets and the surface, must exceed 150 degrees.
- This allows it to be corrosion resistant, robust, and mechanically durable.
- All extremely important to a high efficiency cleaning method.
- High oil and water separation makes it ideal for cleaning grime off of Road Signs

SOTA Continued

2. US Patent for collapsible pressure hose

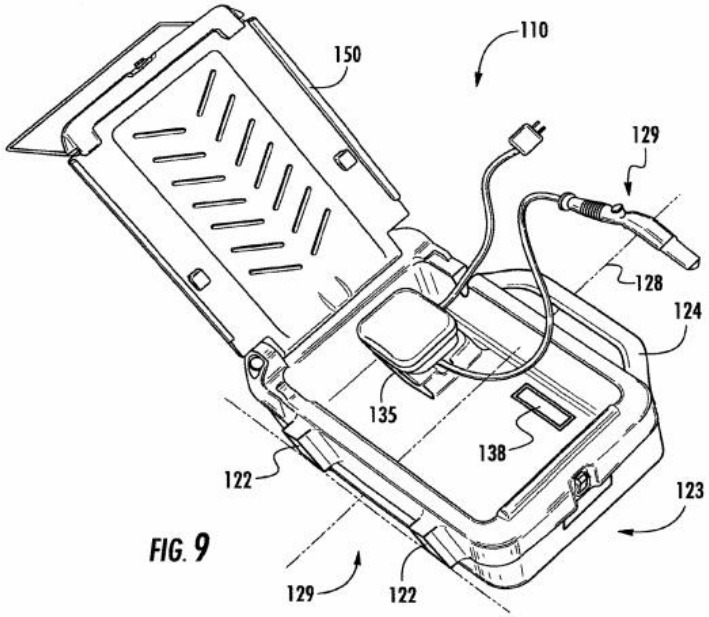


FIG. 9

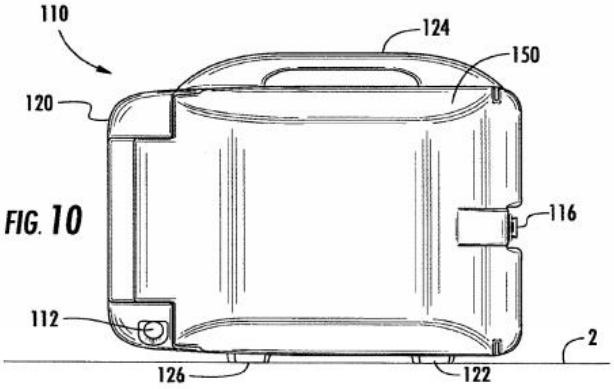
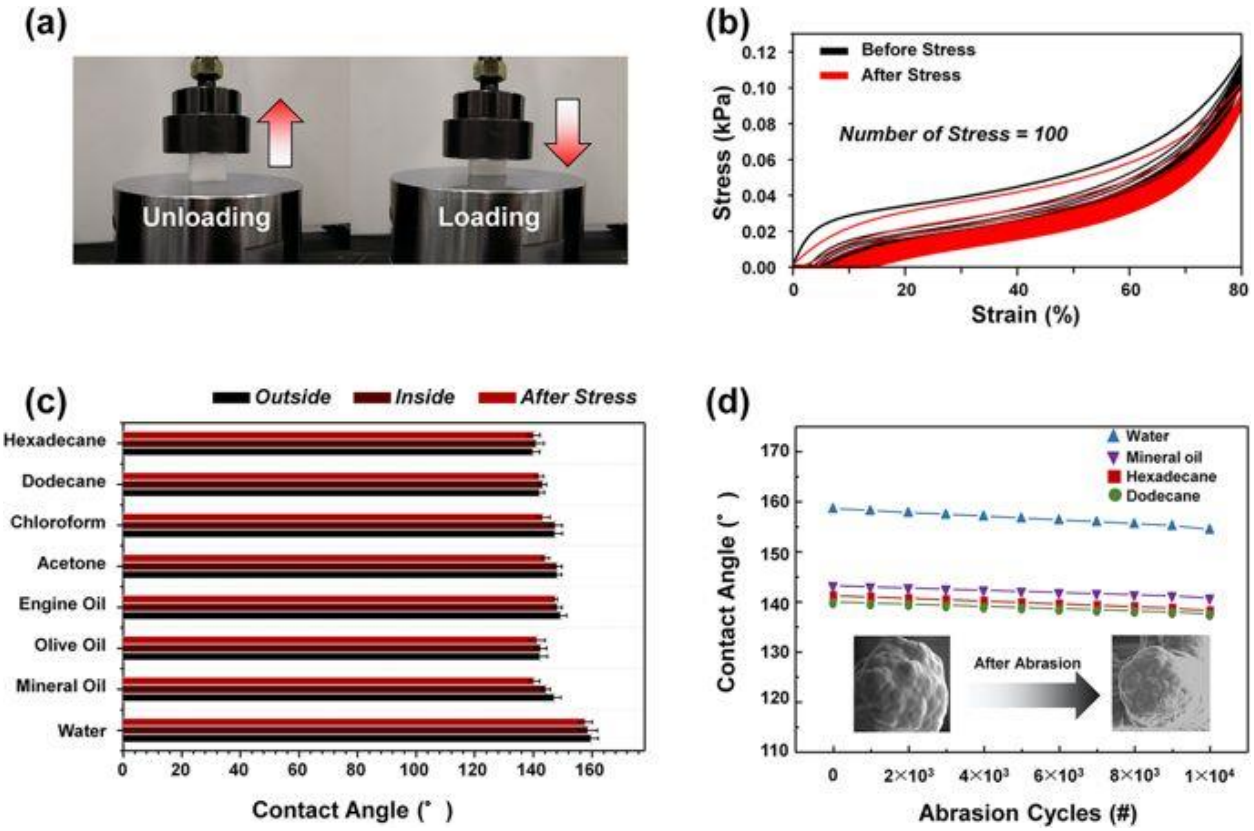


FIG. 10

- Cool collapsible design
- Helps to inspire electromechanical pressure washer that is made portable
- Manual cleaning method though so not ideal

SOTA Continued

3. Peer Reviewed Article on another cleaning material



- Another highly mechanically durable sponge material.
- Graphs show a minimal reduction in contact angle from 160 degrees to about 155 degrees after over 10,000 cycles of loading are applied to it.
- This is imperative to the project design, because we need the material to continue high performance cleaning after multiple uses to ensure efficiency.

Team Meeting 7- Corona Virus Meeting 1

Date: 3/26/20 Topic: New Class Structure

Location: Zoom or Google Hangouts Attendees: Abel and Trent

Important Notes:

1) New communication due to quarantine measures.
   a) Using Zoom
   b) Continue 10:30 am Tues and Thur times.
2) Deliverables
   a) Meeting Minutes and Agenda
   b) Application of Ethics (Individual)
   c) Prototyping (CAD model in Solidworks)
      i) Begin prepping necessary software and practice to refresh memory)
   d) Update Professor Moghaddam (Most likely just send him the progress report.)

Professor Moghaddam was sent the progress report via email and he approved and gave positive remarks about our progress.

Upcoming Assignments:

(See Deliverables Section)

Abel – Submit Minutes and Agenda

Trent- Format email to Moghaddam

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Team Meeting 8- Corona Virus Meeting 2

Date: 3/31/20 Topic: Begin Technical Analysis

Location: Zoom Attendees: All team members

Important Notes:

1) Technical Issues with sound
    a. Abel redownloaded on different computer which fixed issues
2) Deliverables
    a. Meeting Minutes and Agenda
    b. Peer Evals
3) Technical analyses due on 4/17
    a. Begin looking into cost analysis
    b. Think about which one you would want to do

Upcoming Assignments:

(See Deliverables Section)

Abel and Trent – Submit Minutes and Agenda

Peer Evals – Everybody (4/3/20)

Team Meeting 9- Corona Virus Meeting 3

Date: 4/7/20 Topic: Technical Analysis

Location: Zoom Attendees: All team members

Important Notes:

1) Technical Analysis due in 10 days – Individual Assignment but needs team collaboration
    a. Cost analysis – Shuowen
    b. CAD Model – Trent
    c. Structural Analysis – Abel
2) Plan on creating basic dimensions next meeting
3) Deliverables
    a. Technical Analyses
    b. Final Report and Presentation

Upcoming Assignments:

(See Deliverables Section)

Abel and Trent – Submit Minutes and Agenda

Ethics Discussion

Link to NSPE Code of Ethics - https://www.nspe.org/resources/ethics/code-ethics

Good to have this document whenever it is needed. The fundamental canons that are dealing with are project are holding paramount the safety etc. of the public. One of the major concerns during design was to make sure the safety of the drivers below were considered and prioritized as a high customer requirement. The final report also contains a disclaimer that although somewhat hurtful, is entirely understandable and necessary. It states that although we put in a lot of work it was not done by licensed engineers. This was an important point to make in case our work was stumbled upon.

Technical Structural Analysis

Parameters and Assumptions

To begin any of the analyses determining basic dimensions of the rectangular arm components and cylindrical base components were required. To determine this our team decided to begin with a reasonable rectangular arm with dimensions of 12x18 and 1-inch thick aluminum. This gave us a large enough cross-sectional area that can be decreased with each attaching arm. The aluminum material was used due to its lightweight capabilities while maintaining a relatively high modulus of elasticity and reduced costs. The overall length of the fully extended boom arm needed to reach across a 6-lane highway that results in a 76-foot arm span. The first and largest of the arms has an overall length of 22-feet, while the three consecutive arms all have a length of 18-feet with decreasing areas. The arms counterweight had to be relatively small in volume due to the size limitations of highway infrastructures like sound barriers. Lead was chosen due to its low cost and high density, which will help maximize the volume limitations of the counterweight. The other two support systems will be cables with one being attached to the top of the cylindrical support and in tension with the end of the boom arm. The other will be attached at the top of the support as well and in tension with a cable wench located in the truck bed. One of the last assumptions and potentially most important was to reduce the overall weight, and therefore moment produced by half because of the truss system that would be used instead of the rectangular beams. The rectangular beams were used to simplify both the SolidWorks model and the technical analyses. A truss system would allow us to use less than 50 percent of the material suggested here, so we chose to maintain a conservative value with only a 50 percent reduction. Finally, the analysis will be done assuming static equilibrium to ensure no tipping due to moment occurs. Below is a diagram and list of important dimensions that were used in calculating the moments at the designated section cut.

$V1 = 14784\ in^3 \quad V2 = 10368\ in^3 \quad V3 = 8640\ in^3 \quad V4 = 6912\ in^3 \quad V5 = 6804\ in^3$

$L1 = 264\ in \quad L2 = 216\ in \quad L3 = 216\ in \quad L4 = 216\ in \quad L5 = 31.5\ in$

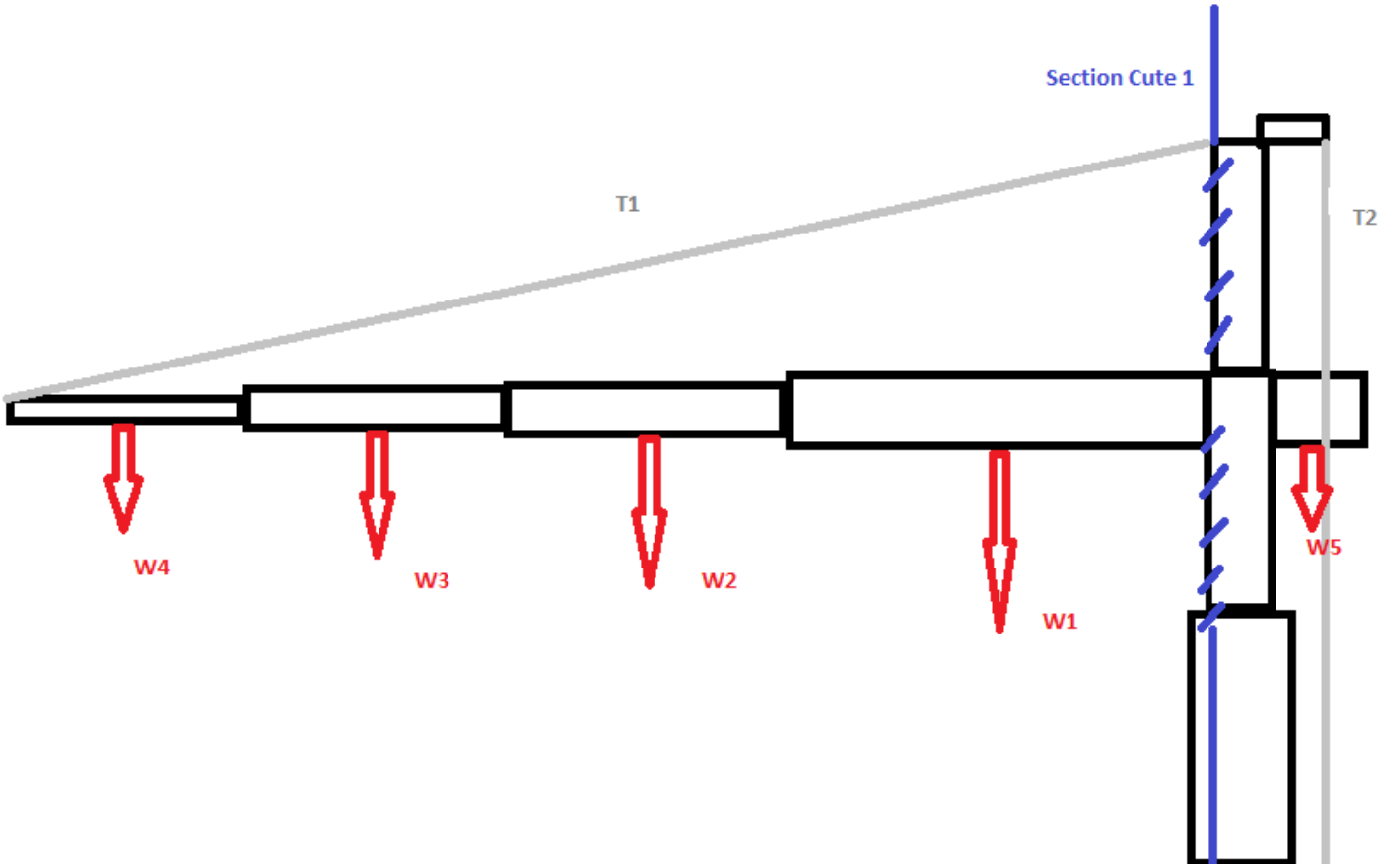

Figure 1. Telescoping Arm Static Diagram

Calculations

The first calculations were to determine the approximate weights (lb f) of the arms. To do this the volumes of each beam were multiplied by the density of aluminum or lead to estimate their weight.

$$W\ (lb\ f) = V\ (in^3) * d\ \left(\frac{lb}{in^3}\right)$$

$$W1 = 14784 * 0.098$$

$$W1 = \theta\theta\theta 1448.8\ lb\ f$$

With the weights determined, the next step was to develop two equation to help solve for the two unknown tensions required to support the telescoping arm. T2 is assumed to be a purely vertical support, but T1 needs to be resolved into its vertical and horizontal components. Before the two equations can be created simple trigonometry can be used to determine the max cable length, degree of action, and the vertical/horizontal components.

$$a^2 + b^2 = c^2$$

$$(912\ in)^2 + (96\ in)^2 = H = 917\ in$$

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$$tan^{-1}\left(\frac{b}{a}\right) = \theta = 6° \; above \; the \; horizontal$$

$$T1x = Tcos\theta \; (lb\; f)$$

$$T1y = Tsin\theta \; (lb\; f)$$

The two equations that will be used to help determine suitable tensile supports are derived using static equilibrium. The basic principle is that moments that are causing the device to rotate counterclockwise need to have equal and opposite moments that cause clockwise rotation. The other equation consists of the same principle but simply in the vertical axis to ensure the device is not moving up or down. Reminder that the overall weight of the boom arm is being reduced by 50 percent to accommodate the proposed truss design.

$$\sum M\;(lb * in) = \frac{1}{2}[-W1(L1) - W2(L1 + L2) - W3(L1 + L2 + L3) - W4(L)] + W5(L5) + T1y(L) + T2(L5) = 0$$

$$\sum M\;(lb * in) = \; -718044 + T1y(912) + T2(22.5) = 0 \quad \textbf{Equation 1}$$

$$\sum Fy\;(lb\; f) = \frac{1}{2}(-W1 - W2 - W3 - W4) - W5 + T1y + T2$$

$$\sum Fy\;(lb\; f) = 4782.1 + T1y + T2 = 0 \qquad \textbf{Equation 2}$$

Using systems of equations to simplify the two equations the two cable wenches will need to supply a force of

$$T1 > 6600\; lb\; f$$

$$T2 \; > 4100\; lb\; f$$

Results Discussion

The back of the envelope equations helped determine the amount of force required by the two cable wenches in order to counteract the moment caused by the weight of the boom arm. One of the largest observations is the difference in force required for the two cables. T1 is much higher due to the extreme angle it's subjected to, so much of the force is in the horizontal direction. To lower the value our team can consider raising the anchor for the cable to help increase the angle. The main result from the calculations is knowing the specifications of the cable wenches required to support the device at its full extension. The calculations also confirm that the original dimensions chosen for the arm will be adequate for the final design.

Final Report (Key Takeaways)

Executive Summary

At the beginning of the semester our team was tasked with creating a device that could safely clean highway signs in diverse settings, while maintaining constant traffic flow. The faculty advisor and client, Dr. Hesam Moghaddam, provided us with a list of constraints: the device needed to be operated by one person on the shoulder of the highway, no interruption to traffic flow, no damage to the signs, and complying with all OSHA regulations. It was also clear through our discussion that ensuring a clean road sign and the safety to the drivers below was the top priority. With this our team began researching current solutions to the cleaning method, deployment of the arm, and highway environments/procedures. During this research it became clear that a major difficulty was going to be accessing the signs from potential distances up to 72 ft from the shoulder of the road. Multiple designs were considered but eventually ruled out due to OSHA regulations, safety hazards, or complexity. The final deployment method was eventually chosen to be a lightweight telescoping truss system that could expand from 28 ft up to 76 feet to satisfy the diverse highway environments. The largest issue related to the cleaning method was to ensure any materials used to clean the sign needed to be retrieved to ensure safety to the drivers below. To achieve this our team proposes using dry ice blasting to achieve a clean and reflective sign. Dry ice blasting consists of immediate sublimation and effectively eliminates the need for any collection of the material. Once both designs were proposed three technical analyses were conducted to determine economic value, structural integrity, and a CAD model of the design. The Cad model allowed us to gain basic dimensions and a general layout of the overall device. With those dimensions estimated weights were calculated to conduct a structural analysis to determine if the device would tip when the boom arm was extended. This analysis determined two cable winches approximating 5000 *lbs f* each would be required to keep the device stable at full extension. The cost analysis confirmed a manageable budget considering the government clientele and life capabilities of the cleaning device. In conclusion, the Squeegee Squad proposes using a commercial truck mounted with a telescoping boom arm that will utilize dry ice blasting to clean overhead highway signs across the United States.

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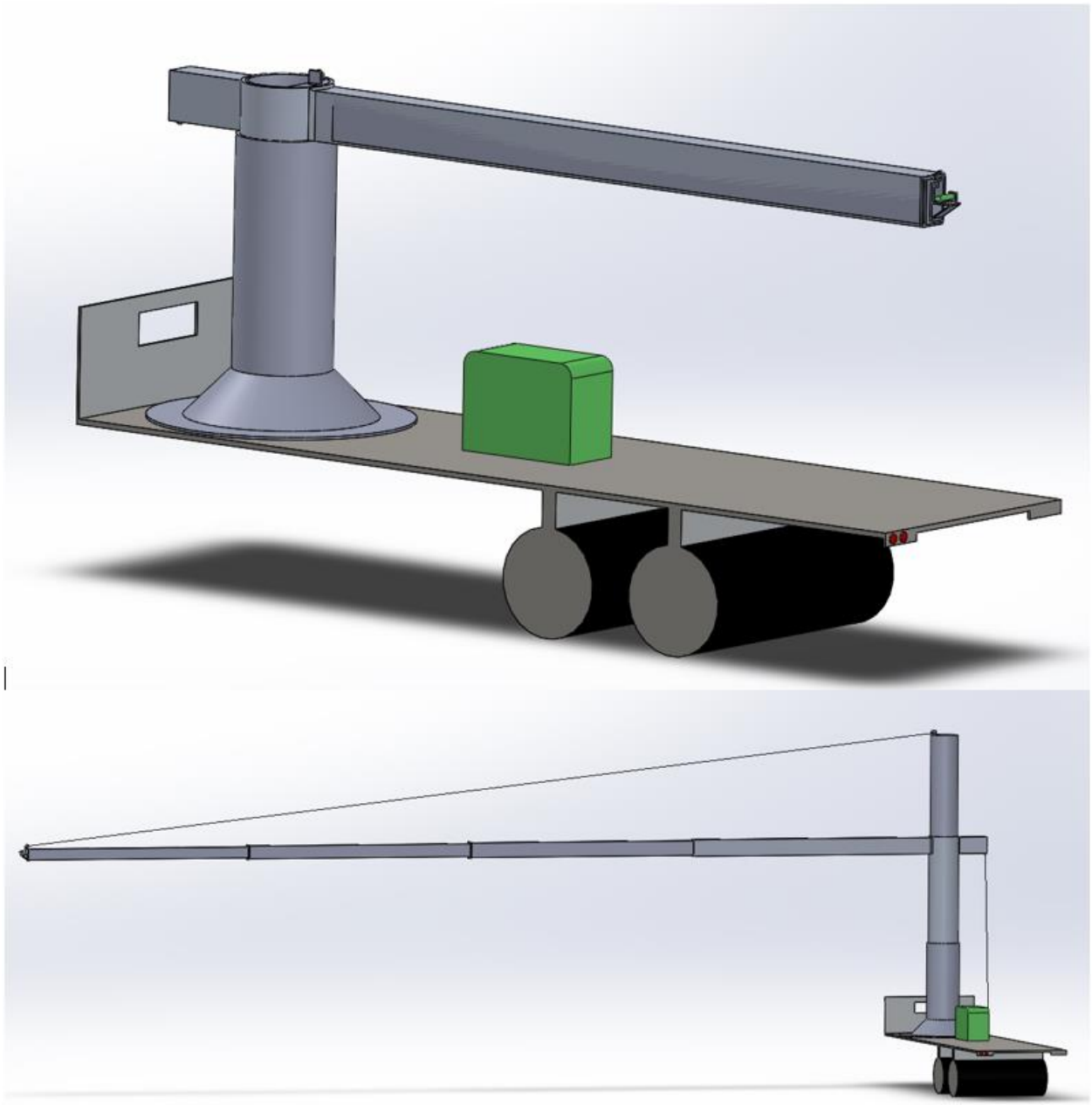

Trent Todd's CAD Model

9. Project Management

From the beginning of the project we had a diverse group with a variety of skill sets. Multiple members also had experience in surface cleaning projects. Throughout the project the group faced a shift in team personnel and issues regarding participation. However, even with these circumstances the team produced exceptional quality and timely work. Below in [Fig.9-1, 9-2, 9-3] is the Gantt chart that was produced to help keep track of the project deliverables. We were

able to accomplish deadlines due to consistent and productive team meetings that took place twice a week.

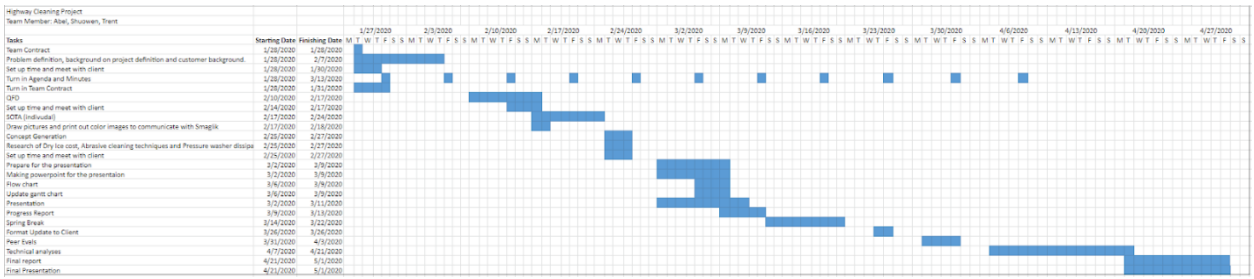

Figure 9-1: Gantt Chart

Tasks	Starting Date	Finishing Date
Team Contract	1/28/2020	1/28/2020
Problem definition, background on project definition and customer background.	1/28/2020	2/7/2020
Set up time and meet with client	1/28/2020	1/30/2020
Turn in Agenda and Minutes	1/28/2020	3/13/2020
Turn in Team Contract	1/28/2020	1/31/2020
QFD	2/10/2020	2/17/2020
Set up time and meet with client	2/14/2020	2/17/2020
SOTA (indivudal)	2/17/2020	2/24/2020
Draw pictures and print out color images to communicate with Smaglik	2/17/2020	2/18/2020
Concept Generation	2/25/2020	2/27/2020
Research of Dry Ice cost, Abrasive cleaning techniques and Pressure washer dissipa	2/25/2020	2/27/2020
Set up time and meet with client	2/25/2020	2/27/2020
Prepare for the presentation	3/2/2020	3/9/2020
Making powerpoint for the presentaion	3/2/2020	3/9/2020
Flow chart	3/6/2020	3/9/2020
Update gantt chart	3/6/2020	3/9/2020
Presentation	3/2/2020	3/11/2020
Progress Report	3/9/2020	3/13/2020
Spring Break	3/14/2020	3/22/2020
Format Update to Client	3/26/2020	3/26/2020
Peer Evals	3/31/2020	4/3/2020
Technical analyses	4/7/2020	4/21/2020
Final report	4/21/2020	5/1/2020
Final Presentation	4/21/2020	5/1/2020

Figure 9-2: Tasks Zoomed

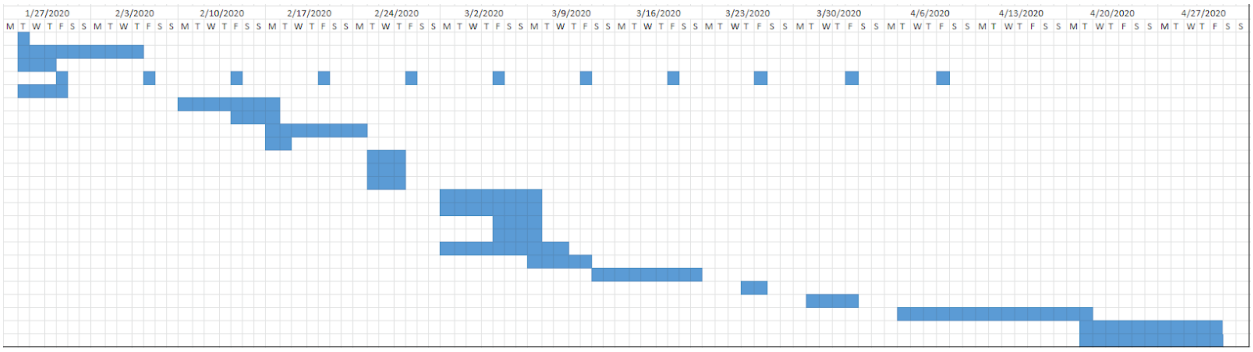

Figure 9-3: Timeline zoomed

10. Conclusion & Future Work

The next steps in the design process is to begin prototyping the two major mechanical components. The dry ice blasting method needs to be tested on regulation road signs to determine if the abrasive cleaning method restores the minimum reflectivity, without causing any damage to the sign. The telescoping truss system needs to be redesigned a little bit to ensure proper weight to strength ratios. Using aluminum or a low-grade steel should ensure the truss systems integrity. Also in order to reach signs that are less than 22 feet away since that is the roughly the collapsed length that will be protruding above the road, the arms will need to rotate towards the front of the truck and the dry ice nozzle will have to pivot accordingly.

Following the success of the prototyping, large-scale manufacturing would begin and an open line of communication with government highway agencies would be started to ensure an efficient purchasing process. Overall the team is happy with the quality of work provided especially considering some of the large problems encountered, we are confident that our design meets all the qualifications and will perform adequately once the correct modifications are made, mainly being: reducing weight, and creating a pivoting system for the spray nozzle. This project was able to provide an opportunity to improve on our engineering skills and gain much needed experience.