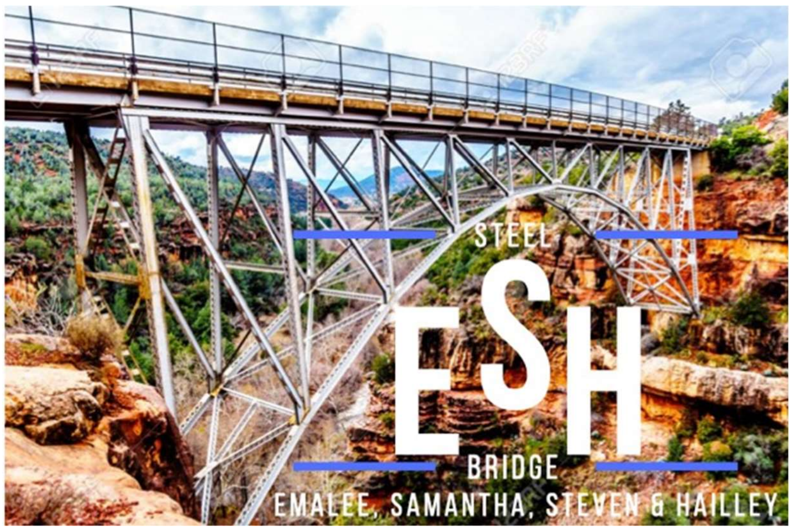
College of Engineering, Informatics, and Applied Sciences




Steel Bridge Competition 2020

ESH

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**Final Project Proposal**

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# 1.0 Project Understanding

## 1.1 Project Purpose

The purpose of the Steel Bridge competition is to do a case study of an area and to create a 1:10 scale model of a limited access bridge. The proposed bridge in the case study provided by American Institute of Steel Construction (AISC) is to be used as a pedestrian, equestrian, and bicyclist trail over the Missouri River at Katy Trail State Park. In the scenario, the bridge is being proposed because the current trail continues to be washed out during storm events. The proposed bridge should be a short-span skewed bridge that runs parallel to the new waterway that was a product of a storm event. A feasibility study will be done to assess the strength, stability, and serviceability under standard loads.

The bridge will be constructed, fabricated, and designed with regard to the 2020 Student Steel Bridge Competition. Aesthetics, structural cost, construction cost, and construction duration are all considerations that will be made in the judging of each bridge. Several South-West universities will compete in a regional event called the Pacific Southwest Conference to receive a spot in the national event to win the design build contract from the Katy Trail State Park engineering associates.

## 1.2 Project Background

This project is a competition capstone for the AISC steel bridge competition. The Pacific Southwest Region AISC 2020 Competition will be located at California State University Fullerton. Students from various colleges in the Pacific Southwest region 4 will compete with their steel bridge designs to best combat a provided real world scenario. This real world scenario is described in the AISC 2020 Steel Bridge Competition Rules.

In previous years, the NAU steel bridge has had mixed placement results. In the 2019 PSWC conference, the bridge team was disqualified due to rule 11.1. A weld fractured, and it was therefore classified as damaged. In 2018, the steel bridge team placed 8th overall, with 3rd place for Display, 4th place for stiffness, 4th place for efficiency, 5th place for lightness, 8th place for economy, and 9th place for construction speed.

### 1.2.1 Scoring

The Steel Bridge competition involves scoring of the student made bridge designs. The lowest scoring team in each category will win the competition. Categories for scoring are listed in the AISC 2020 rules as aesthetics, construction speed, lightness, stiffness, construction economy, structural efficiency, and overall performance. For the aesthetic portion of the competition, the bridge design and poster with description of the design will be judged. The balance, proportion, design exactness, identification, and poster design/completeness is graded. For construction speed, the team to construct the bridge in the shortest amount of time will win. The lightness portion of the competition, the lightest bridge will win. Stiffness is awarded to the team with the lowest deflection. Construction economy is awarded to the bridge with the lowest cost, taking into account persons constructing the bridge and time of construction. Structural efficiency will be awarded to the bridge with the lowest structural cost. Finally, overall performance will be awarded to the bridge with the lowest score in construction cost, structural cost, and violations.

### 1.2.2 Rules

The rules for the AISC 2020 Steel Bridge Competition are focused on the steel material, the components of the bridge, the measurements of the bridge, the functionality of the bridge, the usability, the connection safety, inspectability, construction/pre-construction conditions, time to build, uniqueness of design, and safety. Specifications for each of these sections are listed in the AISC 2020 Steel Bridge Competition Rules.

## 1.3 Technical Considerations

Technical considerations for this project include structural design/analysis, materials selection, connection analysis and selection, fabrication, and construction of the steel bridge.

### 1.3.1 Structural Design and Analysis

RISA 3D will be used to model and analyze the expected performance of the bridge under competition conditions. After the analysis of the bridge, modifications will be made to the model and the new design will be evaluated to create a more efficient design.

### 1.3.2 Material Selection

Research into the different steel grades, tubes, rods, and plates that are available on the markets will determine what materials are best suited for the bridge. The factors that will affect this are strength, weight, cost, and the member location in the bridge design. Material testing will be done in RISA and strength testing will be done for different tubing and shapes.

### 1.3.3 Connection Analysis and Selection

The connections used in the design of the steel bridge will be analyzed for ease of construction and to minimize slippage between members. Previous years have used sleeve connections as well as gusset plates. Some connections will be modeled in RISA 3D and AutoCAD, but most of the connection designs will be completed by hand. Connections will be analyzed for efficiency. The factors that will affect connection selection are ease of construction, cost, and the deflection results.

### 1.3.4 Shop Drawings

Shop drawings will be created in AutoCAD; these drawings will serve as the blueprint to be sent to K-Zell Metals - the sponsor that will cut the pieces. The drawings will also be used by the Mingus Welding Team to do the welding and connections.

### 1.3.5 Fabrication

Each steel member must first be cut to its proper length per the design before fabrication can be done. The type of welding will also need to be established prior to ensure that all equipment is on hand and the strength of the welds will be consistent with the analysis of the modeled strength. In addition to welding, holes will need to be drilled into members that intend to have a bolt holding them together.

### 1.3.6 Constructability

Once the bridge pieces are completed by the Mingus Welding Team, the Steel Bridge Team can begin to assemble the bridge according to the shop drawings. It is imperative that each member fits as it was designed to fit and behaves as it was designed to behave. The team will become very comfortable with the design in preparation for the competition. Additionally, multiple practices will be done to ensure the team knows how to assemble the bridge by memory without referencing any material, making it easier to assemble quickly at conference in front of an audience. Constructability is important for competition, as the team will be timed during construction. It is imperative that team practices multiple times to ensure readiness for competition.

## 1.4 Potential Challenges

The project will pose many tasks that are difficult and potentially challenging for the team members.

### 1.4.1 Unique Constraints and Criteria

The design must be kept in a tight "envelope" for sizing. The constraints limit the placement of steel members so that an open area is in the middle of the bridge, allowing foot traffic to cross over it. Figure 1.3 shows a plan view of the placement of the footings and the allowable construction area. Figure 1.4 gives a cross sectional view of the bridge envelope. The biggest challenge is to create a functional and unique design according to the given constraints of size, weight, load capability, and aesthetics. The bridge must be able to function under the loading conditions, but also be unique to the other competing teams. By further researching different materials and bridge designs, the team will be able to create a unique bridge design.

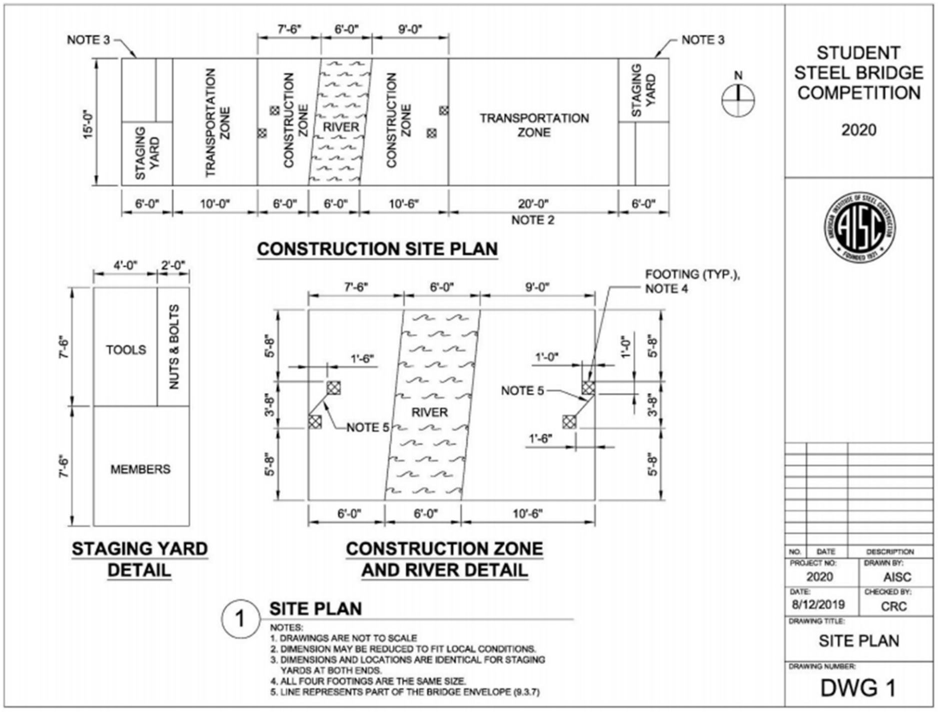



*Figure 1.1 Plan View of Site Plan*

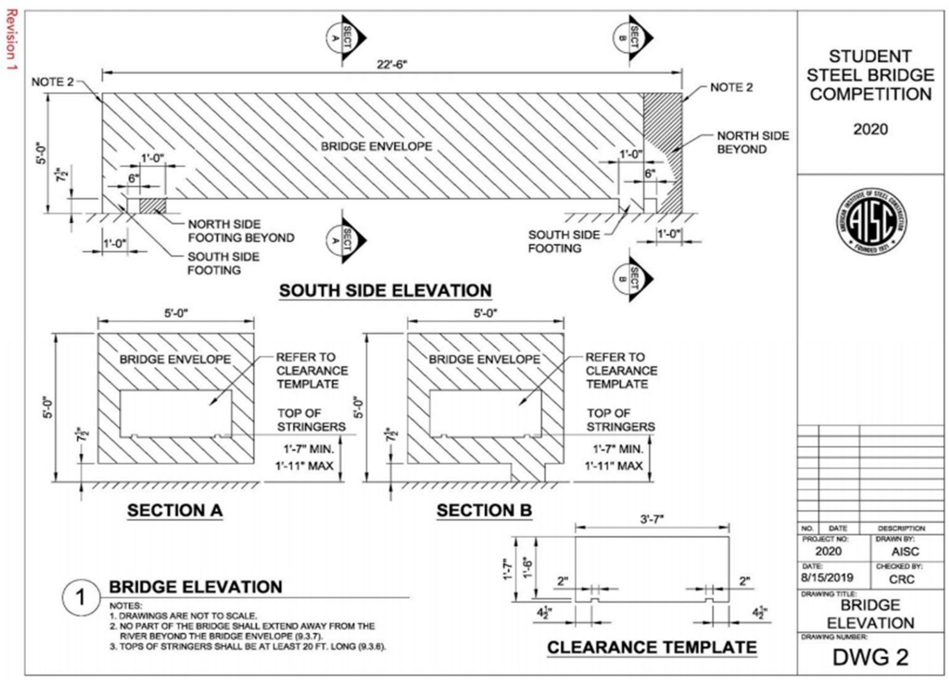



*Figure 1.2. Cross Sectional View of Bridge Elevation and Envelopes*

### 1.4.2 Geographic challenges

One of the main challenges in this project is dealing with the geographic location of resources. All of the team's resources are spread out over Arizona. The steel for the bridge is located in Page from Page Steel, the cutting of the steel is located in Phoenix from K-Zell Metals, the fabrication is located in Cottonwood from Mingus High School, and the bolts are located in Flagstaff from Copper State.

## 1.5 Stakeholders

The stakeholders for this competition are the client, Katy Trail State Park, Northern Arizona University (NAU), the Civil Engineering Department, and the American Society of Civil Engineers (ASCE) student chapter at NAU. The Katy Trail State Park is the immediate stakeholder as the project will benefit their park and the community that surrounds it. Northern Arizona is a stakeholder because the steel bridge is a direct representation of NAU and their students. In the event of a high score, NAU, the Civil Engineering department, and the ASCE student chapter receives recognition and increases the representation of all groups.

# 2.0 Scope of Work

## 2.1 Task 1: Research

### 2.1.1 Analysis Methods

A final RISA 3D model will be made with the beam members' length, spacing, steel types, and potential loading combinations. The connections will be tested by loading them with the amount of load consistent with what will be applied during competition. The connections will be designed to receive a maximum moment provided by RISA. Hand calculations may need to be done to model the connection reaction and members.

### 2.1.2 RISA 3D

RISA is a structural analysis program that allows bridge designs to be built and analyzed. Learning the basics of this program is essential to start designing a bridge. Before any designs can be completed, training on how to input data and where functions are located must be known. Once the basic bridges are drawn, designing can be completed. The deflection and behavior will be modeled in RISA 3D to analyze the bridge design.

### 2.1.3 Bridge Types

The team will research different types of bridges that can be potentially made from steel. There are arch, beam, cantilever, truss, girder, suspension, and cable style bridges to consider. Last year, the team used a truss design with an arch. While the year prior used a simple beam bridge. A variety of designs will allow the team to better understand the context of the project and gain a stronger understanding of design.

### 2.1.4 Connections

A connection is how the members are linked together. The AISC rules state that each member connection should include a nut and bolt. The team will look at types of plates and slip connection methods. Plate connections include a piece that is welded to the member and a bolt that is threaded through connecting members. Bolted connections resist shear and axial movements. The team will look at types of bolted connections and where they are necessary in the design. Additionally, slip connections link members together by fitting one piece into another. Although a slip connection can be oriented different ways, it will always resist the moment. The team will look into safe and reliable practices used by previous teams before finalizing the connections.

### 2.1.5 Materials

Steel can come in a variety of forms, including cold-rolled, hot-rolled, high-carbon, stainless steel, and steel with a mixture of different metals such as cobalt or aluminum. The type of steel selected will be one that is more suitable for withstanding large loads, yet is light enough to make the bridge competitive.

## 2.2 Task 2: Analysis

### 2.2.1 Bridge Type

Using the provided envelope the team must keep the bridge lower than two feet. The provided height parameter eliminates arches, cable style, suspension and traditional trusses as bridge type options. A cantilever bridge will not be used because of loading and constructability.

### 2.2.2 Member Analysis

Each individual steel member on the bridge needs to be analyzed for its conformity to the rules, and it's overall performance as part of the bridge. The cross section shape and dimensions for the members will be chosen based on numerous factors, including the compromise between weight, price, strength, and constructability. Additionally, as there are members that perform different functions within the bridge, some members may have different thicknesses or dimensions than others to maximize their performance. Time will be allocated to test out different combinations of member sizes and shapes until the right blend is found using RISA 3D. An important criteria to consider is constructability and execution for fabrication and competition.

Our calculations and analysis will be based on an assumed modulus of elasticity of 29,000 ksi for steel. The team will take the steel donated by Page Steel and test the strength in the lab to ensure the assumptions are correct. Additionally, the team will test the yield strength of the steel to make sure the type of steel being used will be competitive at competition.

### 2.2.3 Connection Design

The connections between members on the bridge are designed in RISA to ensure that they support the live loads and that it is constructible during competition. The connections will include a nut and bolt and may include plates and slip connections in a variety of combinations throughout the bridge. The nuts and bolts will need to be added to the CAD drawings and multiple iterations need to be done to test their effectiveness. The plates and slip connections can be designed within RISA in accordance to the members' cross sections and dimensions. The effectiveness, deflection, and constructability will be evaluated at the time of analysis.

### 2.2.4 Material Analysis

Analysis can be done in a modeling software such as RISA and by testing the different metal samples in a lab to see their yield strength and weight per unit length. The team will consider what can be provided and the accessibility when deciding on types of steel.

## 2.3 Task 3: Shop Drawings

The RISA design will be converted into fabrication and construction drawings. Construction Drawings will be created using AutoCAD; this will include a detailed member design and dimension list, a completed bridge isometric, plan view, and elevation view. The drawings will be in compliance with AISC and the rules. Multiple plan, elevation, and cross-section views along the length of the bridge will be made to assist the sponsors with cutting the members to the correct length and welding the bridge and connections together. The drawings are going to be used to communicate the bridges functions and design to K-Zell Metals for fabrication of members. Then, the construction drawings will go to the Mingus Welding team out of Cottonwood, Arizona and they will assist with welding.

## 2.4 Task 4: Fabrication Management

### 2.4.1 K-Zell

The team will remain in contact with K-Zell Metals during the fabrication of the bridge. The process with K-Zell Metals is to send a completed drawing plan set to their company so they can cut the steel to the desired length for members and drill the holes for the connection

### 2.4.2 Mingus Welding

The Mingus Welding Team will then weld the bridge together with our team to piece the bridge together according to the construction plans. The Steel Bridge team will take a management role and oversee production and contribute to welding.

## 2.5 Task 5: Final Product Improvements

The team will have to do some improvements. This task is to ensure the bridge is ready to be competitive at competition. Some typical improvements include redesigning connections to fit the members better, pre-welding the plates to the members and drilling holes for the bolts in preparation for construction, and redesigning bracing members to keep the bridge more stable. Some issues the team anticipates may happen include welding fractures, mislabeled parts for construction, and tight connections that need sanding.

## 2.6 Task 6: Competition Preparation

### 2.6.1 Construction Practice

After receiving the bridge members, the team will practice erecting the bridge for the PSWC competition. This will give the team a chance to learn how to move about the design and construct it in a fast and efficient way. Familiarity with where certain members are placed, the order in which they are placed, and how to use the power tools is key to preparing for construction at competition.

### 2.6.2 Poster and Display

The competition requires a poster, display, and testing. The poster will need to be completed prior to going to competition. It will include the RISA 3D drawing of the design, a short synopsis of the project and bridge selection, explanation of bridge construction, all sponsors, and the free body, shear, and moment diagram.

## 2.7 Task 7: AISC Competition

First, the steel bridge will be constructed for display and the judges will evaluate the aesthetics of the bridge.

Next, the Steel Bridge team will construct the bridge on April 2nd, 2020 using 4-6 NAU students. It will be constructed during the assigned bracket for Northern Arizona University and will take no more than 45 minutes to remain eligible for competition scoring and testing.

After constructing the steel bridge, the team will load the bridge for the lateral loading test. A 75lb load will be placed on the north side of the bridge; a 50lb lateral load will be applied centered on the south side decking units and the sway will be measured.

After the lateral loading, the vertical load test will be done. A total of 2500lbs will be placed on the bridge and the total maximum vertical deflection allowed is 3 inches.

## 2.8 Task 8: Project Management

### 2.8.1 Schedule

To organize time and the work process, a schedule will be made to increase productivity. The schedule will be used to organize due dates for deliverables, team meetings, client meetings, communication with sponsors, and design deadlines. It is important to keep a tight schedule for the team; the design must be completed prior to Thanksgiving break to ensure that Page Steel and Copper State can donate the desired materials. The design will also be sent to K-Zell Metals to ensure there is enough time for fabrication and all members are cut to the desired length. After the metal is cut, the team will ensure it is per the construction drawings. Any changes that need to be made will be done quickly so Mingus Welding has time to do their work. The team will allocate a few weeks for construction practice and final changes prior heading to competition.

### 2.8.2 Sponsor Communication

The team will keep in contact with sponsors to ensure they are willing to work and donate materials and labor. The main communication with the sponsors should involve the design of the bridge and time limitations. Page Steel will be donating steel to the team. K-Zell Metals will be donating their time by cutting the steel and potentially drilling holes in areas that will require a bolted connection. Mingus Welding will be welding steel pieces together and potentially cutting members or drilling holes (as needed). Copper State Bolt and Nut Company will be donating nuts and bolts to the team for use with the plated connections.

### 2.8.3 Meetings

Meetings will be scheduled with the team, the advisor, and mentors. These meetings will be frequent to have a great understanding of what is expected. Team meetings will occur around 2-3 times a week. Mentor and advisor meetings will occur when needed. For each meeting, an agenda with notes will be created. This agenda is used to reference, capture important information, and create activity due dates. Each meeting with the team, advisors, and mentors will have activities with the corresponding due date assigned. The team is expected to complete each activity by the due date to ensure the next meeting will run smoothly. Meetings will involve time for design, research, RISA tutorials, and question/response.

### 2.8.4 Deliverables

#### 2.8.4.1 30% Deliverables

The 30% deliverables include a report, a presentation, a bridge design for analysis, and the team having completed the RISA 3D training. The 30% implies that we are 30% done with designing the bridge, therefore, only 30% of work for the design is shown.

#### 2.8.4.2 60% Deliverables

The 60% deliverables include a report, a presentation, a completed bridge design, and the completed shop drawings to be sent to K-Zell Metals and the Mingus Welding team. The 60% deliverables will show 60% of the work completed for the bridge design.

#### 2.8.4.3 90% Deliverables

The 90% deliverables include a report, a presentation, a fabricated bridge, and construction practice for the PSWC competition in April 2020. This deliverable also includes a 90%

completed website for the capstone team. The 90% deliverables will show all of the work for the completed design with only a few things left to edit and correct.

#### 2.8.4.4 Final Deliverables
The final deliverables include a final design report, a completed bridge, having completed the PSWC competition and a final presentation. All designing, fabrication, and construction will be completed and explained fully at this time.

#### 2.8.4.5 Website
The website will be used to keep the information alive and usable for future teams. The website documents the entire design process, contact information for each team member and advisor, and results of the competition.

### 2.8.5 Fundraising
In order to obtain the necessary funding for fabrication, construction, and competition, the team will complete several fundraising efforts. Additionally, the team has several sponsorships that will donate material, connection materials, and time. The money from the fundraisers will be used for travel to and from the competition and traveling to the sponsors.

## 2.9 Task 9: Impacts
The students on the team will gain valuable technical knowledge in the engineering field. The three pillars of interest are environmental, economic, and social impacts. The students will learn more about structural analysis, fabrication, construction, and cost estimation processes. In addition, real world experience such as communicating to team members, advisors, clients, and different companies involved in the project is beneficial to everyone. This allows the students to see how many different pieces there are to engineering design.

## 2.10 Exclusions
The steel bridge team will not complete tasks outside of the scope. The team will not be designing footings, completing geotechnical requirements, surveying, traffic planning, hydrology, or hydraulics. The team is only responsible for structural analysis, fabrication, construction, reporting, and following the AISC rules.

# 3.0 Schedule
## 3.1 Tasks
The major tasks for this project are research, analysis, shop drawings creation, fabrication management, final product improvements, competition preparation, AISC competition, and Project Management. The duration of each task is found in Appendix A. The provided GANTT chart is expected to take place from August 26, 2019 to April 20, 2020. The proposed total duration will be 170 days.

## 3.2 Critical Path

The critical path for the project is the sequence of tasks that must be completed for the final product to be made. Certain tasks are omitted from the critical path if they are not directly necessary for the bridge to be designed and fabricated. The Steel Bridge Project critical path is as follows:

1. Task 1.3 Bridge Type Research
2. Task 2.1 Bridge Type Analysis
3. Task 2.2 Member Analysis
4. Task 2.3 Connection Design
5. Task 2.4 Material Analysis
6. Task 3.1 Shop Drawings
7. Task 4.1 K-Zell Metals
8. Task 4.2 Mingus Welding
9. Task 5 Final Product Improvement
10. Task 6.1 Competition Preparation
11. Task 7 AISC Competition

This is the critical path as a delay in any of these tasks will push back the rest of the team's schedule. Researching Bridge Types and selecting a bridge type for our design constraints is crucial to the success of the project. The correct member sizes and materials also play a crucial part in the success of the project as these will dictate if the bridge will be able to carry the design load at the AISC competition. The member analysis will also give the team the stress in the steel and at the joints that will allow us to create connections that will be able to withstand these stresses. The shop drawings are needed for K-Zell Metals, the individuals who will be cutting the steel into members, and the Mingus Welding team so that the bridge can be fabricated on time and correctly. If any of these groups deliver incorrectly cut or welded steel the schedule will be pushed back as new steel may need to be ordered, recut, and welded. The final product improvement and competition preparation are crucial as these events need to be completed for the steel bridge team to be ready for competition and competitive at competition.

# 4.0 Staffing

## 4.1 Personnel Classification

The project includes several people within the company, the Senior Engineer (SENG), Engineer (ENG), Engineer in Training (EIT), Intern, Lab Assistance (LAB), and an Administrative Assistant (AA). Every member of the team will rotate through these positions.

## 4.2 Qualifications

The team consists of four senior engineering students with different engineering backgrounds. Below is the qualifications of each team member to speak toward their ability to complete this project.

Steven Bloomfield

Steven has worked on the transportation design project for the Pacific Southwest Conference. Steven has experience with scheduling multiple projects as the Commander's Action Group Commander for Air Force ROTC program at Northern Arizona University. Steven has held the vice president, president, and treasurer positions for NAU Honor Guard.

Samantha Cole

Samantha has held the secretary and president positions with the American Society of Civil Engineers student chapter at Northern Arizona University. She has worked on the transportation design project for 2 years for the Pacific Southwest Conference, and has been a mentee for the steel bridge team for 2 years as well. Internships with Kimley-Horn in the land development team and Trace Consulting in the roadway and aviation group has given Sam strong CAD skills and a solid foundation in engineering design.

Hailley Ndubizu

Hailley has been an intern with Coconino County Public Works for the past year. She also has experience as a Project Coordinator with the Coconino County Facilities department. Additionally, Hailley has project manager experience through Public Works. And is the current treasurer of the National Society of Black engineers.

Emalee Sena

Emalee has a stellar work ethic, for example she is on the path to complete the engineering program in three and a half years. Though she has no prior work experience, she provides the team will excellent time management skills and technical work.

## 4.3 Work Plan

The Engineer in Training will be taking over the majority of the RISA design and analysis as well as the meetings with the client, grading instructor, and team. The mid-level engineer will be devoting a lot of their time to the meetings, design and analysis with RISA, and the background research. The senior engineer will oversee all tasks and assist in a few areas such as design analysis, the AISC competition, and project management. The Lab Tech will be working many hours on fabrication management, material analysis, and attending meetings. The Intern will spend a lot of time attending meetings and learning more about the project, as well as doing background research and assisting the engineers with the design. Because the intern is young and still learning, they will be slower and less efficient when working on their work compared to more experienced engineers, so that is why there are a lot of hours assigned to them. The Administrative Assistant is primarily assigned to taking notes and generating agendas for the meetings with the client, grading instructor, and team. Additionally, the Administrative Assistant will work on the reports and presentations for the deliverables throughout the project.

The Work Plan Matrix is shown in detail in Appendix B.

# 5.0 Cost of Engineering Services

The cost of engineering service required for this project is calculated and put into a table located in Appendix C: Cost Summary. The following sections describe the reason for each cost.

## 5.1 Personnel cost

The following section describes the personnel required to work on the project with the billing rate per hour, and the total cost for the professional's service. The table below shows the billing rates per hour for reference.

*Table 5.1: Billing Rates*

| Personnel | Billing Rate ($/hr) |
|---|---|
| SENG | 200 |
| ENG | 137 |
| EIT | 72 |
| LAB | 90 |
| AA | 67 |

In order to have a complete bridge design, the various team members required are paid for their work. The team members that are needed to have working project management are: Senior Engineer, Engineer, Engineer in Training, Lab Technician, and Administrative Assistant. Our team used HDR Engineering's pay rate for reference when creating the total costs for the required personnel.

<u>Senior Engineer</u>

The Senior Engineer will work for approximately 82 hours with a rate of pay $200 per hour. This pay rate was chosen because the senior engineer has over 10 years of experience, they oversee the project, participate in group meetings, and check the work of other engineers to ensure the calculations are correct. In addition to this, the average pay rate for a Senior Engineer at HDR Engineering is around $195 an hour. This results in a total pay of $16,400.00 paid for the Senior Engineer working on the project.

Engineer

The Engineer will work for 179 hours and will get paid $137 per hour. The Engineer has over 4 years of experience, oversees the Engineer in Training's work, participates in group meetings, completes calculations for the project, and designs the bridge. For an average engineer at HDR Engineering the hourly pay rate is $145. Because our Engineer will be working like the average engineer, a similar pay rate is awarded. The total cost for the Engineer working on this project is $24,523.00.

Engineer in Training

The Engineer in Training will work on the project for 582 hours. The Engineer in Training has 0-4 years of experience, completes designs and calculations, does research, participates in group meetings, and helps the Lab Technician. The hourly pay rate for the Engineer in Training is $72 because the average pay rate for HDR Engineering's Engineer in Training is around $95. The total cost of the Engineer in Training for this project is $41,904.00.

Lab Technician

The Lab Technician will work on the project for 142 hours. The Lab Technician will perform work that requires member testing, participate in group meetings, do fabrication management, and do bridge construction. The hourly pay rate for the Lab Technician is $90; this is because it is near the average Lab Technician pay at HDR Engineering of $105. The total cost for the Lab Technician participating in the project is $12,780.00.

Administrative Assistant

The Administrative Assistant will be completing 133 hours of work. The work completed will consist of writing the meeting minutes, reports, and presentations. The hourly rate of pay will be $67 due to the work involved. This is justified because the average pay rate for the Administrative Assistant at HDR Engineering is around $70. The total cost for the Administrative Assistant to work on the project $8,911.00.

## 5.2 Total cost

Total personnel

The combined personnel required to work for the project to run smoothly is the Senior Engineer, Engineer, Engineer in Training, Lab technician, and Administrative Assistant. The total combined hours of work for the project is 1118. The combined cost of personnel for the project is $104,518.00.

Travel

The travel required for this project will involve driving to the competition located at CSU Fullerton. A car rental will be required to drive to the competition. The competition is six days so a van rental from NAU will be required. NAU's van rental rate is $60 per day. For six days the total cost is $360. Driving to the competition and back will be a total of 900 miles. The federal reimbursement rate for driving is $0.58 per mile. This results in a total cost of $522 for driving. The competition will be 5 days and will require a hotel stay for 10 nights due to needing two rooms, one for males and one for females. The hotel rate is $220.00 per room. The total cost for the hotel stay will be $2,200.00. In addition to the competition, driving will also be required for fabrication management. This involves driving to Mingus High School for welding, K-Zell for the members, Copper State for nuts and bolts, and Page Steel for the steel. The total amount of driving will be 450 miles at a reimbursement rate of $0.58 per mile based on the federal amount. The total travel cost for fabrication management is $261.00.

Supplies

The supplies needed for the project involve materials and tools. The materials are steel members, nuts, and bolts. The total cost for the steel, nuts, and bolts would be $2000. However, since we are getting all of our materials donated the actual cost for the materials are $0. Therefore, the value of the materials and services donated is estimated in the budget in case the sponsors fall through. This conservative spending amount will also account for miscellaneous expenditures that won't be covered by the donations. The tools needed for the project are welding supplies, saws, and drills. This will total at $550 for use during our fabrication. However, because we are using school equipment, the actual cost is $0.

Subcontracting

Subcontracting for the project will be for welding. The Mingus Welding Team is allowing us to use their advice and equipment to weld the bridge together. Since this team is donating their time and equipment, the total cost for subcontracting is $0.

Total cost

The total combined cost for all sections contributing to the project is $110,461.00. This amount includes all cost of all personnel working on the project, all travel, supplies, and subcontracting.

# Appendix

## Appendix A: GANTT Chart

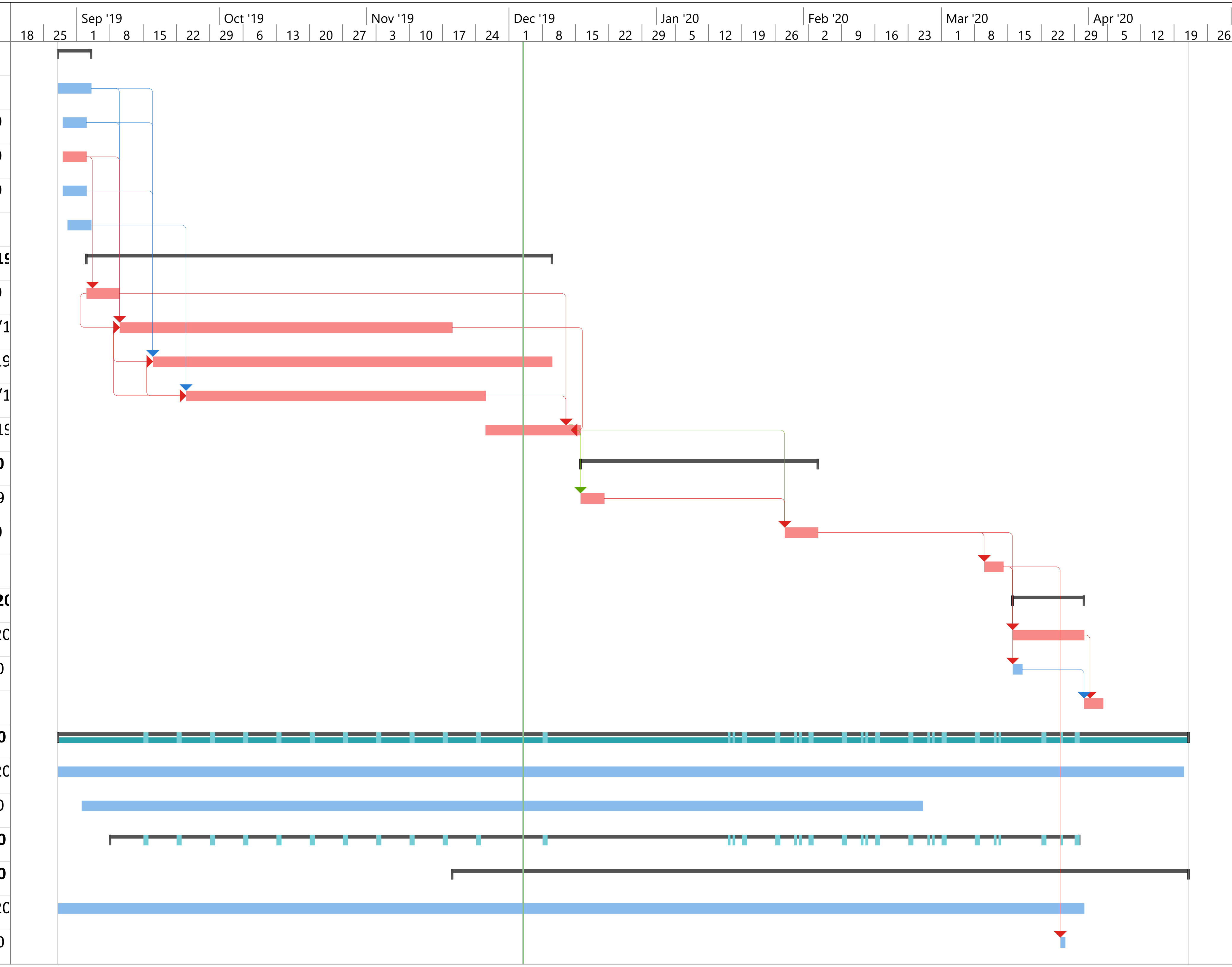
# Appendix B: Work Plan Matrix

## Appendix C: Cost Summary Table

| Classification | Units | Rate | Cost |
|---|---|---|---|
| SENG | 82 | $200 | $16,400.00 |
| ENG | 179 | $137 | $24,523.00 |
| EIT | 582 | $72 | $41,904.00 |
| LAB | 142 | $90 | $12,780.00 |
| AA | 133 | $67 | $8,911.00 |
| **Total Personnel** | 1118 | | $104,518.00 |
| Competition | 5 nights and 2 rooms | $220/room | $2,200 |
| | Vehicle Rental for 6 days | $60/day | $360 |
| | 900 mi | $.58/mi | $522 |
| Fabrication Management | 450 mi | $.58/mi | $261 |
| Materials | | | $2,000 |
| Tools | | | $500 |
| Mingus Welding | | | $100 |
| **Total Cost** | | | $110,461.00 |

| Task | Personnel | | | | | Sum |
|---|---|---|---|---|---|---|
| | SENG | ENG | EIT | Lab | AA | |
| **Task 1: Research** | 8 | 16 | 90 | 8 | 0 | 122 |
| 1.1 Analysis Methods | 1 | 2 | 16 | 0 | 0 | 19 |
| 1.2 RISA 3D | 2 | 4 | 12 | 0 | 0 | 18 |
| 1.3 Bridge Types | 2 | 4 | 24 | 4 | 0 | 34 |
| 1.4 Connections | 1.5 | 3 | 14 | 4 | 0 | 22.5 |
| 1.5 Materials | 1.5 | 3 | 24 | 0 | 0 | 28.5 |
| **Task 2: Design and Analysis** | 20 | 41 | 102 | 32 | 0 | 195 |
| 2.1 Bridge Type | 2 | 6 | 14 | 0 | 0 | 22 |
| 2.2 Member Analysis | 8 | 18 | 38 | 0 | 0 | 64 |
| 2.3 Connection Design | 8 | 12 | 32 | 12 | 0 | 64 |
| 2.4 Material Analysis | 2 | 5 | 18 | 20 | 0 | 45 |
| **Task 3: Shop Drawings** | 4 | 4 | 40 | 4 | 2 | 54 |
| 3.1 Shop Drawings | 4 | 4 | 40 | 4 | 2 | 54 |
| **Task 4: Fabrication Management** | 4 | 8 | 62 | 40 | 8 | 122 |
| 4.1 K-Zell | 1 | 2 | 6 | 0 | 4 | 13 |
| 4.2 Member Cutting | 2 | 4 | 32 | 24 | 0 | 62 |
| 4.3 Mingus Welding | 1 | 2 | 24 | 16 | 4 | 47 |
| **Task 5: Final Product Improvement** | 2 | 4 | 24 | 16 | 0 | 46 |
| 5.1 Final Product Improvement | 2 | 4 | 24 | 16 | 0 | 46 |
| **Task 6: Competition Preparation** | 3 | 6 | 24 | 2 | 9 | 44 |
| 6.1 Competition Preparation | 2 | 4 | 20 | 2 | 6 | 34 |
| 6.2 Poster and Display | 1 | 2 | 4 | 0 | 3 | 10 |
| **Task 7: AISC Competition** | 6 | 12 | 24 | 2 | 2 | 46 |
| **Task 8: Project Management** | 35 | 88 | 216 | 38 | 112 | 489 |
| 8.1 Schedule Management | 6 | 3 | 4 | 0 | 6 | 19 |
| 8.2 Sponsor Communication | 4 | 6 | 5 | 0 | 6 | 21 |
| 8.3 Meetings | 12 | 62 | 140 | 30 | 70 | 314 |
| 8.4 30% Deliverables | 2 | 3 | 12 | 2 | 3 | 22 |
| 8.5 60% Deliverables | 2 | 4 | 12 | 2 | 3 | 23 |
| 8.6 90% Deliverables | 3 | 6 | 16 | 1 | 6 | 32 |
| 8.7 Final Deliverables | 4 | 2 | 13 | 1 | 6 | 26 |
| 8.8 Fundraising | 2 | 2 | 14 | 2 | 12 | 32 |
| **Personnel Hours** | 82 | 179 | 582 | 142 | 133 | 1118 |

| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Task 1: Research** | **5 days** | **Wed 8/28/19** | **Tue 9/3/19** |
| 2 | 1.1 Analysis Methods | 5 days | Wed 8/28/19 | Tue 9/3/19 |
| 3 | 1.2 RISA 3D | 3 days | Thu 8/29/19 | Mon 9/2/19 |
| 4 | 1.3 Bridge Types | 3 days | Thu 8/29/19 | Mon 9/2/19 |
| 5 | 1.4 Connections | 3 days | Thu 8/29/19 | Mon 9/2/19 |
| 6 | 1.5 Materials | 3 days | Fri 8/30/19 | Tue 9/3/19 |
| 7 | **Task 2: Design and Analysis** | **70 days** | **Tue 9/3/19** | **Mon 12/9/19** |
| 8 | 2.1 Bridge Type | 5 days | Tue 9/3/19 | Mon 9/9/19 |
| 9 | 2.2 Member Analysis | 50 days | Tue 9/10/19 | Mon 11/18/1 |
| 10 | 2.3 Connection Design | 60 days | Tue 9/17/19 | Mon 12/9/19 |
| 11 | 2.4 Material Analysis | 45 days | Tue 9/24/19 | Mon 11/25/1 |
| 12 | 3.1 Shop Drawings | 15 days | Tue 11/26/19 | Sun 12/15/19 |
| 13 | **Task 4: Fabrication Management** | **36 days** | **Mon 12/16/1** | **Mon 2/3/20** |
| 14 | 4.1 K-Zell | 5 days | Mon 12/16/1 | Fri 12/20/19 |
| 15 | 4.2 Mingus Welding | 5 days | Tue 1/28/20 | Mon 2/3/20 |
| 16 | 5.1 Final Product Improvement | 4 days | Tue 3/10/20 | Fri 3/13/20 |
| 17 | **Task 6: Competition Preparation** | **11 days** | **Mon 3/16/20** | **Mon 3/30/20** |
| 18 | 6.1 Construction Practice | 11 days | Mon 3/16/20 | Mon 3/30/20 |
| 19 | 6.2 Poster and Display | 2 days | Mon 3/16/20 | Tue 3/17/20 |
| 20 | Task 7: AISC Competition | 4 days | Tue 3/31/20 | Fri 4/3/20 |
| 21 | **Task 8: Project Management** | **170 days** | **Wed 8/28/19** | **Tue 4/21/20** |
| 22 | 8.1 Schedule | 169 days | Wed 8/28/19 | Mon 4/20/20 |
| 23 | 8.2 Sponsor Communication | 127 days | Mon 9/2/19 | Tue 2/25/20 |
| 24 | **8.3 Meetings** | **145 days** | **Sun 9/8/19** | **Sun 3/29/20** |
| 63 | **8.4 Deliverables** | **111 days** | **Tue 11/19/19** | **Tue 4/21/20** |
| 69 | 8.5 Fundraising | 154 days | Wed 8/28/19 | Mon 3/30/20 |
| 70 | Task 9: Impacts | 1 day | Thu 3/26/20 | Thu 3/26/20 |




Project: Capstone Gantt Chart.m
Date: Wed 12/4/19

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Critical, Critical Split, Progress, Manual Progress