2024 – 2025 ASCE TIMBER-STRONG

Project Final Proposal

ASTROJACKS ENGINEERING

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CENE 476

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Equations

(NOT APPLICABLE)

Abbreviations

APA: American Plywood Association

ASCE: American Society of Civil Engineers

ASD: Allowable Stress Design

AWC: American Wood Council

BIM: Building Information Modeling

CECMEE: Civil Engineer, Construction Management, and Environmental Engineer

INT: Engineering Intern

ISWS: Intermountain Southwest Student Symposium

NDS: National Design Specification

RFI: Request for Information

SAF: Safety Officer

SENG: Senior Engineer

SIPS: Structural Insulated Panels

SPWS: Special Design Provisions for Wind and Seismic

SST: Simpson Strong-Tie

STENG: Structural Engineer

SUPR: Superintendent

Section 1: Project Understanding

1.1 Project Purpose

The ASCE 2024 – 2025 Timber Strong Student Competition allows civil engineering students the opportunity to get hands on experience with real world timber structural design and construction. The focus of the project is to design and construct a sustainable, aesthetically pleasing, and structurally sound two-story, light-framed wood structure. AWC, SST and APA ask students to use the design-build method and create an innovative, durable structure.

Wood is emphasized as the main material for this competition due to its renewable nature and environmental benefits. It reduces carbon footprints, compared to more traditional materials like steel and concrete. The competition allows students to get experience with structural engineering and construction practices, for example, design analysis, structural drawings, BIM, and construction planning. Students will apply their knowledge from courses at Northern Arizona University to successfully implement concepts like project management, project development, design skills, teamwork, communication, and structural analysis.

1.2 Project Background

Since 2018, student members of the NAU ASCE Chapter have been participating in the Simpson Strong Tie Timber-Strong competition. There have been many changes over the years in the project's overall scope that have allowed the competition to be more technical and competitive.

The majority of the project's work will be completed on NAU's campus in Flagstaff, AZ, shown in figure 1. During the initial phases of the project, most of the work will be done within the Northern Arizona University's Engineering Building. This work includes the creation of the overall design, the structural analysis and design of all the structural members, the BIM modeling, and the preparation of the construction drawings. Once this work is complete, prefabrication of the building's panels will be done at the NAU 'Farm.' The Farm, also known as the Civil Engineering, Construction Management, and Environmental Engineering (CECMEE) field station is shown in Figure 2.

Upon completion of all prefabricated elements of the building, the final construction will occur in Tucson, AZ on University of Arizona's campus at the 2025 ASCE ISWS Competition.

Figure 1, below, shows the location map of the project, with the two primary work areas highlighted.

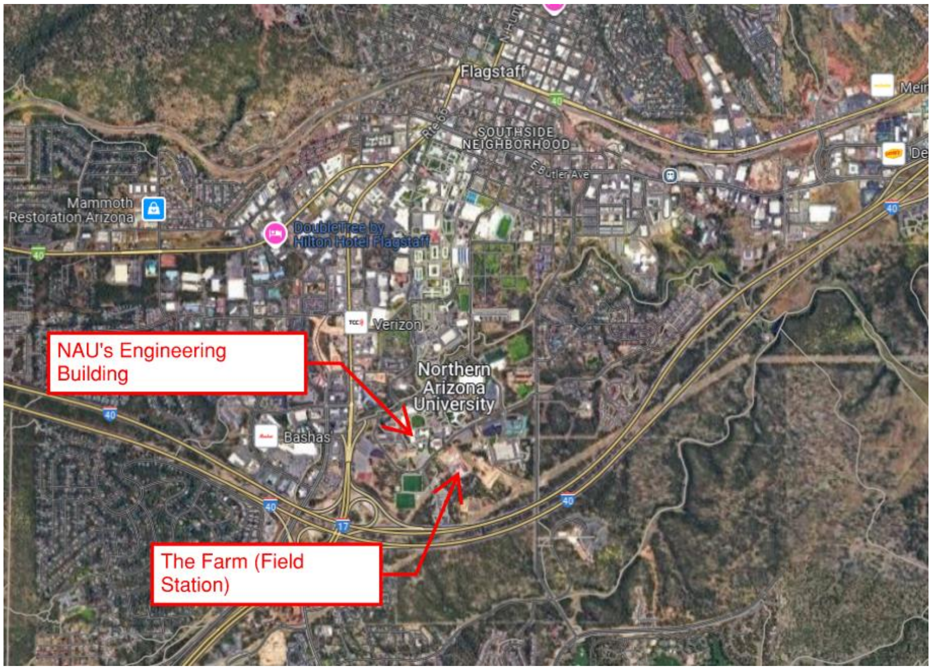

FIGURE 1: LOCATION MAP OF PROJECT

Figure 2, below, shows the vicinity map of the project, including the location where prefabrication of the panels will occur.

FIGURE 2: VICINITY MAP OF PROJECT

1.3 Technical Consideration

The Allowable Stress Design (ASD) method will be used to ensure that the applied loads are within the design capacitates. The structural design must meet the project requirements of the Vertical and Horizontal loads along with the dead load of the structure itself.

- Roof Live Load: 20 psf
- Floor Live Load: 50 psf
- Point Load on Cantilever floor beam: 150 lbs
- Lateral seismic load at the roof: 275 plf
- Lateral Seismic load at the floor: 225 plf
- Roof Wind uplift pressure: 30 psf

The construction will take place at the farm over multiple days. The process of constructing the structure will be carried out in phases such as. Phase one is buying the materials. Phase two is prefabricating sections of the structure. Phase three is assembling the structure at the ISWS competition.

1.4 Potential Challenges

As participants of the 2025 Timber-Strong Design Build Competition, there will be instances where our team will encounter complexities within our design and construction process. Being able to address these challenges proactively is crucial for achieving a successful project outcome. Some key challenges our team will face are listed below along with strategies for overcoming them.

Limitations on material are a challenge our team will face due to restrictions on the specific wood types we can use. Douglas Fir (DF), Douglas Fir-Larch (DF-L), Hem-Fir (HF), Southern Pine (SP), and Spruce-Pine-Fir (SPF) are the species groups or engineered wood products the team is limited to use. The team must also ensure all materials are compliant with grading standards. This limitation complicates sourcing materials that would meet both structural requirements and availability. To address this challenge early on, communication with suppliers to confirm availability of materials must take place. If the chosen wood type is not available, an alternative wood type should also be in the talks as a backup plan.

Only having 90 minutes for construction on Build Day is a time constraint that the team must execute effectively to ensure the timber structure is properly put together. This time constraint limits the ability to make real-time adjustments. To meet the time constraint during Build Day, our team must efficiently pre-plan prefabrication of all components, except the roof, and prepare to use necessary tools properly.

The submission and approval of Request for Information (RFIs) and Change Orders is a time constraint. With these strict deadlines, any delay in submitting or addressing RFIs could slow down the project's progress, causing setbacks. Since Change Orders alter the original design and scope, it is within our best interest to process them as quickly as possible. As a team, we must plan to track and submit RFIs and Change Orders to ensure all changes get approved in a timely manner to avoid delays.

Structural instability during Build Day could occur if the required temporary shoring for the cantilevered floor system is not properly placed. This will impose a safety hazard on all team members. To mitigate risks during Build Day, the attached shoring system must be designed to safely support the cantilevered beam without human intervention. Rehearing the installation process ahead of Build Day can help ensure the temporary shoring is properly placed.

Challenges along the design and construction of this project are bound to happen. Being able to address these challenges ahead of time with proper planning will ensure that our team is able to deliver a successful submission.

1.5 Stakeholders

Stakeholders are any person or group involved directly or indirectly in a project. The clients, American Society of Civil Engineers (ASCE) and sponsors American Wood Council (AWC), Simpson Strong-Tie (SST), and The Engineered Wood Association (APA) are all stakeholders because they are encouraging an inclusive culture at the Timber-Strong Design Build Competition by being key financial sponsors and have helped set project objectives. AstroJacks Engineering are stakeholders as they are gaining experience from this Timber-Strong Design Build Competition. Indirect stakeholders include the engineering community who may adopt new practices from this competition. The quality of work that the AstroJacks Engineering does will affect the reputation of Northern Arizona University (NAU) and NAU ASCE Student Chapter, as they depend on an ethical submission. The project's success holds everyone at stake as it is meant to promote a sustainable design and the use of renewable resources in our construction process.

Section 2: Scope of Services / Research Plan

2.1 Task 1: Background Research

Conduct thorough background research providing a solid base for design decisions to fully understand the Timber Strong project requirements and constraints. This task requires AstroJacks Engineering to investigate the competition rules, relevant materials, structural standards, and necessary software tools.

2.1.1 Task 1.1: Competition Rules

This task is to review the 2025 Timber-Strong Design Build Competition Rules. The AstroJacks Engineering must identify key requirements related to the design, construction, and sustainability of the Timber-Strong Project. The goal is to fully understand the competition rules and ensure all design criteria and team requirements are met to have a safe and successful project from beginning to end.

2.1.2 Task 1.2: Material Research

This task explores the different materials specified in the 2025 Timber-Strong Design Build Competition Rules. The material properties (strength, durability, carbon footprint, etc.), environmental impacts, and availability of the materials must be researched for sustainable construction with wood being the primary building material. The goal of this subtask is to ensure material selection creates a sustainable, structurally durable, and aesthetically pleasing structure.

2.1.3 Task 1.3: National Design Specification (NDS) and NDS Supplement for Wood Construction

This task is to study and understand the 2018 National Design Specification (NDS) for Wood Construction. AstroJacks Engineering must review relevant sections of the NDS regarding the structural design criteria and its integrity. The goal of this subtask is to ensure compliance with national standards.

2.1.4 Task 1.4: Special Design Provisions for Wind and Seismic (SDPWS)

This task is to study and understand the Special Design Provisions for Wind and Seismic (SDPWS) to consider environmental influences on structural performance. Competition success relies on incorporating principles from the SDPWS to enhance structural resilience.

2.1.5 Task 1.5: Mathcad

AstroJacks Engineering must familiarize themselves with Mathcad engineering computer software, to aid in design verification and analysis. The goal is to be proficient in Mathcad to ensure accurate calculations and to streamline the design process.

2.2 Task 2: Preliminary Design

This task involves the initial design phase, with an emphasis on material selection and fundamental design decisions. The goal is to ensure the project complies with competition criteria and meets all standards.

2.2.1 Task 2.1: Timber Selection

AstroJacks Engineering must research the five acceptable species groups or engineered wood products mentioned in the 2025 Timber-Strong Design Build Competition Rules to ensure the chosen materials meet competition criteria and sustainability goals.

2.2.2 Task 2.2: Initial Design Decisions and Design Matrix

AstroJacks Engineering must create initial design concepts of the building layout and its structural components. A clear design matrix must be established for making a decision that complies with competition criteria.

2.3 Task 3: Design and Analysis

The purpose of this task is to focus on the building's structural analysis to ensure it can withstand lateral loads and gravity loads with the competition's specifications.

2.3.1 Task 3.1: Determination of Gravity Loads

This task requires the calculation and design of vertical loads of the roof and floors (dead and live loads), cantilever floor beam for shear and bending, and point loads at critical locations. The goal is to ensure the structure can withstand anticipated loads.

2.3.2 Task 3.2: Determination of Lateral Loads

This task requires the calculation and design of lateral loads such that the structure resists seismic and wind loads based on allowable stress design (ASD). This includes the design of shear walls and diaphragms. The goal is to ensure the structure's stability and safety.

2.4. Task 4: Roof Design

This task involves all aspects regarding the design of the structure's roof in accordance with the 2025 Timber-Strong rules.

2.4.1 Task 4.1: Roof Gravity Strength Design

This task is to design the roof to withstand all potential gravity loads imposed on it. Once the lumber type and grade is selected, the appropriate NDS Supplement will be used to determine the stress capacities so that member sizes can be designed with respect to both flexure and shear. Maximum shear and moment values determined previously will be set equal to the appropriate equations to solve for beam depth, and values will be factored down according to the NDS Supplement. This task ensures the roof will be able successfully carry all applied loads.

2.4.2 Task 4.2: Diaphragm Design

The purpose of this task is to ensure that the roof diaphragm will have enough capacity to carry all applied loads.

2.4.2.1 Task 4.2.1: Seismic Load and Internal Shear

Using the applied factored seismic loads, the maximum shear values inflicted upon the diaphragm will be determined by use engineering statics concepts.

2.4.2.2 Task 4.2.2: Design for Strength

This task covers the design of the diaphragm for shear. Using the SDPWS, nominal unit shear capacities for blocked sheathed wood framed diaphragms will be found according to panel thickness, nail size, nail length, and nail spacing.

2.4.2.3 Task 4.2.3: Design for Serviceability

This task ensures that the roof diaphragm's deflection is acceptable within the appropriate design serviceability limits. The calculations used to find the deflection will be taken from the SDPWS and then compared to the appropriate allowable story drift according to ASCE 7-22.

2.4.3 Task 4.3: Chord Design

The purpose of this task is to design the roof chord, which is the member responsible for resisting flexural forces imposed by the diaphragm load.

2.4.3.1 Task 4.3.1: Seismic Load and Internal Compression

This task is to calculate the maximum moment imposed on the chord from the applied factored seismic load.

2.4.3.2 Task 4.3.2: Design Strength

This task is being done to design the chord member to resist bending. Using the NDS Supplement for the appropriate lumber type and grade, a capacity will be determined, and sizing of the chord member will be based upon the calculated loads versus the bending capacities.

2.4.3.3 Task 4.3.3: Design for Serviceability

This task ensures that the calculated deflections of the chord are within the appropriate serviceability limits. Deflection calculations will be using the beam deflection equation and then compared to allowable beam deflection limits set forth by AWC.

2.4.4 Task 4.4: Collector Design

The purpose of this task is to design the roof collectors, which are members responsible for resisting shear forces imposed on the roof due to the applied factored seismic load.

2.4.4.1 Task 4.4.1: Seismic Loading and Internal Shear

This task involves the calculation of the maximum shear in the collector due seismic load. Once found, the shear will be converted into a stress using the cross-sectional area of the collector.

2.4.4.2 Task 4.4.2: Design for Strength

This task ensures that the collector can safely carry the required shear due to the applied factored seismic load. Using the NDS Supplement, the appropriate shear capacity for stress parallel to the grain of the wood will be determined and then compared to the stresses found in the members.

2.4.5 Task 4.5: Rafter Tie Down Design

The purpose of this task is to design the appropriate tie down hardware required to resist any uplift imposed by wind loading found in the roof diaphragm.

2.4.5.1 Task 4.5.1: Wind Uplift Load

This task involves determining the forces found in the roof due to wind loading. The roof wind uplift pressure found in the 2025 Timber-Strong rules will be compared to the member's tributary area to determine the imposed loading.

2.4.5.2 Task 4.5.2: Design for Strength

Using the appropriate Simpson Strong Tie product manual, design capacities for the tie down hardware will be compared to the calculated uplift forces imposed on the roof.

2.5 Task 5: Wall Design

The purpose of this task is to design all wall framing members and stud spacings to resist both flexure and shear.

2.5.1 Task 5.1: Wall Gravity Strength Design

The loading found due to the appropriate gravity loads set forth by the 2025 Timber-Strong rules will be used in comparison to appropriate capacities found in the NWS Supplement to select member sizes and spacings that can safely resist the loading.

2.5.2 Task 5.2: Wall Lateral Design

This task involves designing the lateral shear wall, the hold down hardware, and the anchor bolts for both the first and second story walls.

2.5.2.1 Task 5.2.1: Shear Wall Design

Using the applied factored seismic loading compared to the calculated internal member stresses, the shear wall will be designed to safely resist shear forces.

2.5.2.2 Task 5.2.2: Seismic Load and Internal Shear

This task is to determine the diaphragm reactions due to the seismic loading set forth by the 2025 Timber-Strong rules.

2.5.2.3 Task 5.2.3: Wall Design for Strength

This task involves designing the shear wall to safely resist any imposed shear forces. Shear walls will be designed using FTAO shear wall methods using guidance found in the SDPWS. Using the applied factored seismic load, maximum unit shear values will be determined and then compared to nominal unit shear capacities found in the SDPWS according to panel thickness, nail size, nail length, and nail spacing.

2.5.2.4 Task 5.2.4: Wall Design for Serviceability

This task ensures that the calculated deflections for the shear wall are within the appropriate deflection limits. Deflections will be found using the SDPWS shear wall deflection equation, and this value will be compared to the allowable deflection story drift set forth by ASCE 7-22.

2.5.3 Task 5.3: Hold Down and Anchor Bolt Design

The purpose of the hold-down design is to resist the uplift forces caused by lateral loads like seismic loads in this project. The seismic forces can cause overturn and designing hold downs resist that. The purpose of anchor bolt design is to hold the bottom of the walls to foundation to resist shear loads acting parallel to the plane of the wall.

2.5.3.1 Task 5.3.1: Overturning Force
The purpose of design for overturning forces is to resist lateral loads. For this two-story timber structure, it must resist wind and seismic forces which could cause overturning.

2.5.3.2 Task 5.3.2: Design for Strength
The purpose of this task is to use the given loads to design the structure to withstand the conditions. This will allow the structure to score well in competition and be a structurally efficient timber structure.

2.5.4 Task 5.4: Floor Design
The purpose of this task is for the design of the floor gravity strength to support the vertical loads, cantilever deflection to limit vertical and bending movement under point loads, and floor lateral design to ensure stability forces such as wind and seismic. This task is critical for the safety and integrity of the structure.

2.5.4.1 Task 5.4.1: Floor Gravity Strength Design

The purpose of designing for floor gravity strength is to ensure the building is strong and stable to support the load applied to them. This structure is subject to vertical live and dead load so the design must resist failure, sagging and deflection.

2.5.4.2 Task 5.4.2: Cantilever Deflection
The purpose of cantilever deflection design is to limit the amount of vertical movement and bending. With point loads being loaded onto the beam, design for high bending stresses is crucial to ensure the structure will not deflect too far or fail.

2.5.4.3 Task 5.4.3: Floor Lateral Design
The purpose of floor lateral design is to make sure the floor will safely resist lateral forces. For this structure it is subject to wind and seismic loads, designing for these in the floor is crucial for stability and integrity of the building.

2.5.5 Task 5.5: Design Optimization
The purpose of this task is to ensure the structure has been designed properly. Each element is tested and compared to applications, if the element does not pass the test, it will be redesigned before construction.

2.6 Task 6: Modeling
The purpose of this task is to create 2D structural drawings using AutoCAD to visualize the design. A 3D Building Information Modeling to illustrate component interactions for visualizing design efficiency and lowering costs.

2.6.1 Task 6.1: 2D Structural Modeling
The purpose of 2D drawing will help show the overall design of the structure. AutoCAD will be used for this process. The drawings will be used during construction and will be used on competition day to help with building.

2.6.2 Task 6.2: 3D BIM

The purpose of using 3D BIM, especially in Revit, will help show all components of the structure. It will show how each member connects and works together. This will help with design and reduce costs by reducing materials.

2.7 Task 7: Construction

The purpose of this task is to efficiently coordinate the use of materials for prefabrication at the "Farm", making sure it gets properly stored, and prepares builders for assembly within the time frame for competition day.

2.7.1 Task 7.1: Material Acquirement and Prefabrication

The purpose of the task is to efficiently coordinate getting the materials to the "Farm" for prefabrication. The team must accurately coordinate time to get the wood materials and tools to the site. Then properly store the material until it is ready to be used. The entire structure will be prefabricated at the farm before the competition.

2.7.2 Task 7.2: Construction Practices

The purpose of this task is to prepare the builders for competition day. The team will practice assembling the structure in less than 90 minutes. This task will take multiple attempts since the builders will have to get comfortable with putting the structure together correctly.

2.8 Task 8: Deconstruction Plan

The purpose of this task is to create a deconstruction plan for the materials after the competition build day. The materials are to be donated individually to charitable organizations.

2.8.1 Task 8.1: Disassembly

The purpose of this task is to create a plan to disassemble the structure at the end of the competition build day. The structure will be disassembled by starting at the roof and working to the first floor in reverse.

2.8.2 Task 8.2: Plan for Repurpose

The purpose of this task is to find an organization that will repurpose the materials from the structure.

2.9 Task 9: Investigate Project Impacts

The purpose of this task is to investigate the environmental impacts of the structure. The impacts include carbon footprint and sustainability.

2.10 Task 10: Project Deliverables

The purpose of this task is to outline key deliverables of the project, ensuring all aspects of the project deliverable is met for project goals through completion.

2.10.1 Task 10.1: Capstone Deliverables

The purpose of this is to review and stay on track for 30%, 60%, and 90% of the project's submissions for Capstone.

2.10.1.1 Task 10.1.1: 30%

The purpose of this task is to make the team stay on track to complete the final project and proposal. A 30% report will be submitted to Canvas for the team's Grading Instructor to review before the deadline.

2.10.1.2 Task 10.1.2: 60%

The purpose of this task is to make the team stay on track to complete the final project and proposal. A 60% report will be submitted to Canvas for the team's Grading Instructor to review before the deadline. The comments from the 30% report will be resolved in the 60%. This document will be the second draft.

2.10.1.3 Task 10.1.3: 90%

The purpose of this task is to make the team stay on track to complete the final project and proposal. A 90% report will be submitted to Canvas for the team's Grading Instructor to review before the deadline. This will be the third draft that includes comments and feedback from the 30% and 60%.

2.10.1.4 Task 10.1.4: Final Presentation

The purpose of this task is to present to the instructors of CENE 486 a condensed version of the entirety of the project.

2.10.1.5 Task 10.1.5: Final Report and Website

The purpose of this task is to complete a professional document for the project. It will be submitted on canvas by the deadline for the Grading Instructor to approve.

The website will show documents from the project proposal to the construction drawings in a professional display. The website will also include a short biography of the team members and their part in the project.

2.10.2 Task 11: Competition Deliverables

The purpose of this task is to outline key deliverables of the competition, ensuring all aspects of the project deliverable is met for competition standards and project goals through completion.

2.10.1 Task 11.1: Registration and Compliance

The purpose of this task is to inform the judges that a student team from NAU will be participating during build day. The team must submit an Intent and Eligibility Acknowledgement form no later than November 1st at 5pm. The student team must also complete a free ladder safety training course through ladderstafetytraining.org before construction can begin. The certificate must be uploaded onto the teams ASCE Cerberus ftp server.

2.10.2 Task 11.2: Phase 1: Final Project

The purpose of this task is to is to provide the instructors of CENE 486 with a condensed version of the project.

2.10.3 Task 11.3: Phase 2: Structural Drawings and 3D Modeling

The purpose of this task is to use AutoCAD software to use two -dimensional drawing that will be used during the competition. Utilizing the Autodesk Revit (BIM) modeling software the structure will be modeled in three dimensions. It will allow the team a visual of what the product of the design would look like. See 2.6 Task 6 Modeling for more information.

2.10.4 Task 11.4: Phase 3: Presentation

The purpose of this task is to present to the instructors of CENE 486 a condensed version of the project.

2.10.5 Task 11.5: Final RFI and Change Order

The purpose of this task is to send the judges any questions clarifying design criteria on the initial design. The team must submit final questions through 2024 Timer-Strong Design Build RFI 14 days prior to build day. Change orders must be submitted a minimum of seven days prior to building day. This includes changes to any of the previous phase submissions. Change orders cannot be used to revise completed drawing sets.

2.10. 6 Task 11.6: Visual Aid

The purpose of this task is to create a poster that will summarize the details of the project. This poster is to be displayed at the competition building site. The poster is to be 30"x 40" with a foam-core base. It needs to include the drawings, graphics, photos, team names, a table of the calculations of the cantilever beam, calculated carbon stored, material cost, calculated weight, and the factor of safety for the diaphragm and the shear walls.

2.10.7 Task 11.7: Competition Build Day

The purpose of this task is to ensure that the team understands all rules and requirements to receive an adequate score during the competition build. The team captain must attend the captain meeting prior to build day.

The six competition builders will place each element of the structure inside the work area along with any of the tools and materials needed. The team will have a maximum of 90 minutes to complete the construction of the structure.

2.12 Task 12: Project Management

The purpose of this task is to manage the project effectively so that it is finished on schedule, within budget, and to quality standards. Project management will support team cooperation and resource allocation by verifying and reviewing the progress of the project's timeline to allow for corrective actions to be taken if needed.

2.12.1 Task 12.1: Resource Management

AstroJacks Engineering must stay organized in identifying and allocating necessary resources. Resources may include materials, personnel, and tools. The goal of this subtask is to optimize resources to keep a sustainable and efficient project.

2.12.2 Task 12.2: Schedule Management

A detailed project timeline with key milestones and deadlines for each task must be created to maintain the project's critical path within vision. This organization will be through a Ghantt chart, and any meetings will be scheduled through Google Calendar, forty-eight hours (about 2 days) prior to the meeting. The goal oof this subtask is to ensure the competition of each phase is done within a timely manner.

2.12.3 Task 12.3: Meetings

This task ensures effective communication takes place through the organization of various types of meetings. Various meetings include team members and various stakeholders. Meeting agendas and meeting minutes will be documented for each meeting and will be shared with all members.

2.12.3.1 Task 12.3.1: Team Meeting

Team meetings will occur at least once a week. Attendance is required by all team members of AstroJacks Engineering. These meetings will discuss progress, delegate tasks, and address any rising challenges. The goal is to make sure all team members are involved with the project's progress as well as keep everyone engaged.

2.12.3.2 Task 12.3.2: Captain's Meeting

AstroJacks Team Captain, Colton Ray Davis, must attend the mandatory Team Captain's Meeting the day before Build Day, to receive an overview of the event as well as ask any last-minute questions. This task is to ensure Colton is prepared with any information or updates pertaining to the competition.

2.12.3.3 Task 12.3.3: Mentee Meetings

Mentee meetings will occur when necessary. Mentees will be assigned or taught different aspects of the competition. Guidance and support will be obtained by Mentees in these meetings. In the case that mentees do not show up to these meetings, as it is not mandatory, AstroJacks Engineering will utilize this time for the completion of upcoming deliverables.

2.12.3.4 Task 12.3.4: Client Meetings

Client meetings will occur a minimum of once a month to provide project updates or discuss the project's progress and expectations.

2.12.3.5 Task 12.3.5: Technical Advisors Meeting

AstroJacks Engineering must meet with the Technical Advisor at least six times, two in Fall of 2024 and the remaining four in Spring 2025. These meetings will be utilized to obtain technical and practical advice to avoid critical mistakes. Meeting minutes must be provided within forty-eight hours (about 2 days) of the meeting. Meeting request via Google Calendar must include meeting agenda.

2.12.3.6 Task 12.3.6: Grading Instructor Meeting

AstroJacks Engineering must meet with the Grading instructor at least six times, two in Fall of 2024 and the remaining four in Spring 2025. These meetings will be utilized to receive feedback or answer any questions regarding project submissions to ensure the team understands grading expectations.

2.13 Exclusions

The management scope for this project will exclude the use of prefabricated roof systems with sheathing attachments and Structural Insulated Panels (SIPS), as both are not permitted by the ASCE Timber-Strong rule criteria. Additionally, AstroJacks Engineering will not be manually supporting the structure during construction on Build Day, nor will the structure be anchored, in accordance with competition guidelines. The design will also not account for lateral wind loads, rain and snow loads, or construction live loading. AstroJacks Engineering is committed to ensuring the safety of all team members and will not engage in activities which may jeopardize the safety of team members.

Section 3: Schedule

The total duration of the project schedule is 161 working days. The schedule does not show any work being done from December 14th through January 12th, as this is Northern Arizona University's winter break, and no work will be done during this time.

Listed below are the start and finish dates for each task:

- **Task 1 (Background Research)** → 8/27/24-9/5/24
- **Task 2 (Preliminary Design)** → 9/6/24-10/4/24
- **Task 3 (Design and Analysis)** → 10/7/24-10/8/24
- **Task 4 (Roof Design)** → 10/9/20-11/5/24
- **Task 5 (Wall Design)** → 11/6/24-12/13/24
- **Task 6 (Modeling)** → 1/13/25-1/28/25
- **Task 7 (Construction)** → 3/3/25-4/4/25
- **Task 8 (Deconstruction)** → 4/11/25-4/11/25
- **Task 9 (Investigate Project Impacts)** → 1/13/25-1/14/25
- **Task 10 (Deliverables)** → 9/27/24-5/6/25

The project schedule also includes deliverable due dates, which are listed below:

Capstone Deliverables:

- **30% Report** → 2/13/25
- **60% Report** → 3/13/25
- **90% Report** → 4/17/25
- **Final Presentation** → 5/2/25
- **Final Report and Website** → 5/6/25

Competition Deliverables:

- **Registration and Compliance** → 11/1/24
- **Phase 1: Final Report** → 1/31/25
- **Phase 2: Structural Drawings and 3D Modeling** → 2/28/25
- **Phase 3: Presentation** → 3/7/25
- **Final RFI and Change Order**→ 3/28/25
- **Visual Aid** → 4/1/25

Task 10 (Deliverables), Task 11 (Competition Deliverables), and Task 12 (Project Management) run throughout the entire duration of the project, as these tasks can be done without the need to wait for predecessors.

Critical Dependencies:

- **Preliminary Design (Task 2)** cannot proceed without completing **Background Research (Task 1)**.

- **Design and Analysis (Task 3)** relies on the outcome of **Preliminary Design (Task 2)**.
- **Roof, Wall, and Floor Designs (Tasks 4 and 5)** depend on the completion of **Design and Analysis (Task 3)**.
- **Modeling (Task 6)** can only be started after **Design (Task 3-5)** is finalized.
- **Construction (Task 7)** is contingent on the prefabrication of materials, which requires finalized designs from **Modeling (Task 6)**.
- **Deliverables (Task 10)** are spread out over time and act as checkpoints that monitor the progress of all previous tasks.

3.1 Critical Path

The critical path shows the main tasks of the project that have a longer duration, and each is essential to completing the project. If one of these tasks is not completed the project will not be able to move forward without the previous task. Starting off with background research then to the preliminary design, structural design and analysis, roof, wall, and floor designs, modeling, and then finally construction and each deliverable. Each of these critical path tasks have a direct impact on the timeline for the project; delays with any of these tasks will affect the overall date of completion.

To ensure the critical path tasks are completed on schedule, there are strategies in place to ensure it will be completed on time. The team is consistently monitoring the Gantt Chart and regularly updating it. This will accurately keep track of progress, as well as planned versus actual completion to make sure nothing is falling behind. The team is allocating their resources wisely and using each team member's strengths to their advantage. Lastly the team holds regular meetings to talk about progress, delegate tasks, and address any issues and delays with the project. This will ensure any issues that do occur get addressed immediately.

Section 4: Staffing Plan

The list below includes all staff positions with their respected abbreviations that AstroJacks Engineering will be using.

List of Staff Titles with Abbreviations:

- SENG: Senior Engineer
- STENG: Structural Engineer
- SUPR: Superintendent
- SAFT: Safety Officer
- INT: Engineering Intern

The following are brief qualifications for each staff position listed above.

- SENG: Senior Engineer

  The Senior Engineer has a bachelor's degree in civil engineering and professional engineering License and Structural Engineering License with extensive years of experience. They possess extensive knowledge of timber structural design principles and are proficient in BIM. The Senior Engineer has strong collaboration skills which allows them to work effectively within the team.

- STENG: Structural Engineer

  The Structural Engineer has a bachelor's degree in civil or structural engineering and has a solid understanding of timber design, including but not limited to load calculations. They are familiar with construction practices and have great collaboration skills to work within the team.

- SUPR: Superintendent

  The Superintendent has a background in construction management and engineering, with a strong understanding of the construction process and site management. They possess leadership skills to oversee project execution and ensure everyone adheres to safety protocols.

- SAFT: Safety Officer

  The Safety Office is knowledgeable about safety regulations within the construction world. They have experience with conducting safety training and risk assessments. The Safety Officer also possesses strong communication skills, which are essential for effectively training and informing team members about safety protocols.

- INT: Engineering Intern

  The Engineering Intern is currently enrolled in a Civil Engineering degree program and possesses basic understanding of engineering principles. They have a basic understanding of design and analysis software, along with a strong eagerness to learn and contribute to the team. They possess effective communication and teamwork skills to be used through the design and construction phase of the project.

The table below shows each task mentioned in Section 2 of AstroJacks Engineering Final Proposal Report and how many hours each team member will contribute. The units of Table 1 below are in hours.

Refer to Appendix C for the complete table with all tasks and sub tasks included.

TABLE 1: STAFFING MATRIX

Position	Task 1 Background Research	Task 2 Preliminary Design	Task 3 Design and Analysis	Task 4 Roof Design	Task 5 Wall Design	Task 6 Modeling	Task 7 Construction	Task 8 Deconstruction Plan	Task 9 Investigate Project Impacts	Task 10 Project Deliverables	Task 11 Project Management	Proposed
SENG	12	30	15	15	20	10	15	2	4	20	10	153
STENG	25	55	20	55	40	20	30	2	6	40	20	313
SUPR	5	14	0	5	5	4	60	1	1	10	10	115
SAFT	5	15	2	5	5	0	50	1	2	10	5	100
INT	2	2	4	4	4	2	20	4	2	1	0	45
Proposed	49	116	41	84	74	36	175	10	15	81	45	726

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Section 5 : Cost of Engineering Services

AstroJacks Engineering has effectively estimated the total cost of engineering services for the proposed project shown in Table 2 below. The table below details personnel costs for each staff member with their respected billable rates. Billable rates are applied to the time identified in the staffing matrix, which accounts for the effort of each staff member involved in the project. Table 2 below also accounts for critical costs components such as travel, lab use, and materials. Travel costs encompass vehicle rental, mileage, hotel, and per diem expenses. Lab use includes not only field station but equipment and tools as well. Materials are focused on the components used to build the 2-story wood lightly framed building.

TABLE 2: COST OF ENGINEERING SERVICES

Description	Quantity	Unit of Measure	Rate $	Cost
Personnel				
Senior Engineer	153	Hr	$260.00	$39,780
Structural Engineer	313	Hr	$200.00	$62,600
Superintendent	115	Hr	$220.00	$25,300
Safety Officer	100	Hr	$75.00	$7,500
Engineering Intern	45	Hr	$20.00	$900
			Subtotal Personnel	$135,180
Travel				
Rental Van	5	Days	$73.54	$368
Driving Mileage	500	Miles	$0.41	$205
Per Diem	4	People ($60 per day for 5 days)	$300.00	$1,200
Hotel Room	4	Nights (4 rooms)	$1,200.00	$4,800
			Subtotal Travel	$6,573
Lab Use				
Field Station "Farm"	7	Days	$100.00	$700
			Subtotal Lab use	$700
Materials				
2x4x8 Hem Fir	70	EA	$5.78	$405
2x4x20 Hem Fir	4	EA	$7.33	$29
OSB Sheet (4x8)	18	EA	$23.36	$420
Fasteners	5	EA	$40.53	$203
Connectors / Hardware	1	LS	$1.00	$500
Paint	10	Gal	$10.00	$100
Primer	10	Gal	$20.00	$200
			Subtotal Material Cost	$1,657
			Total Cost of Engineering Services	**$144,110**

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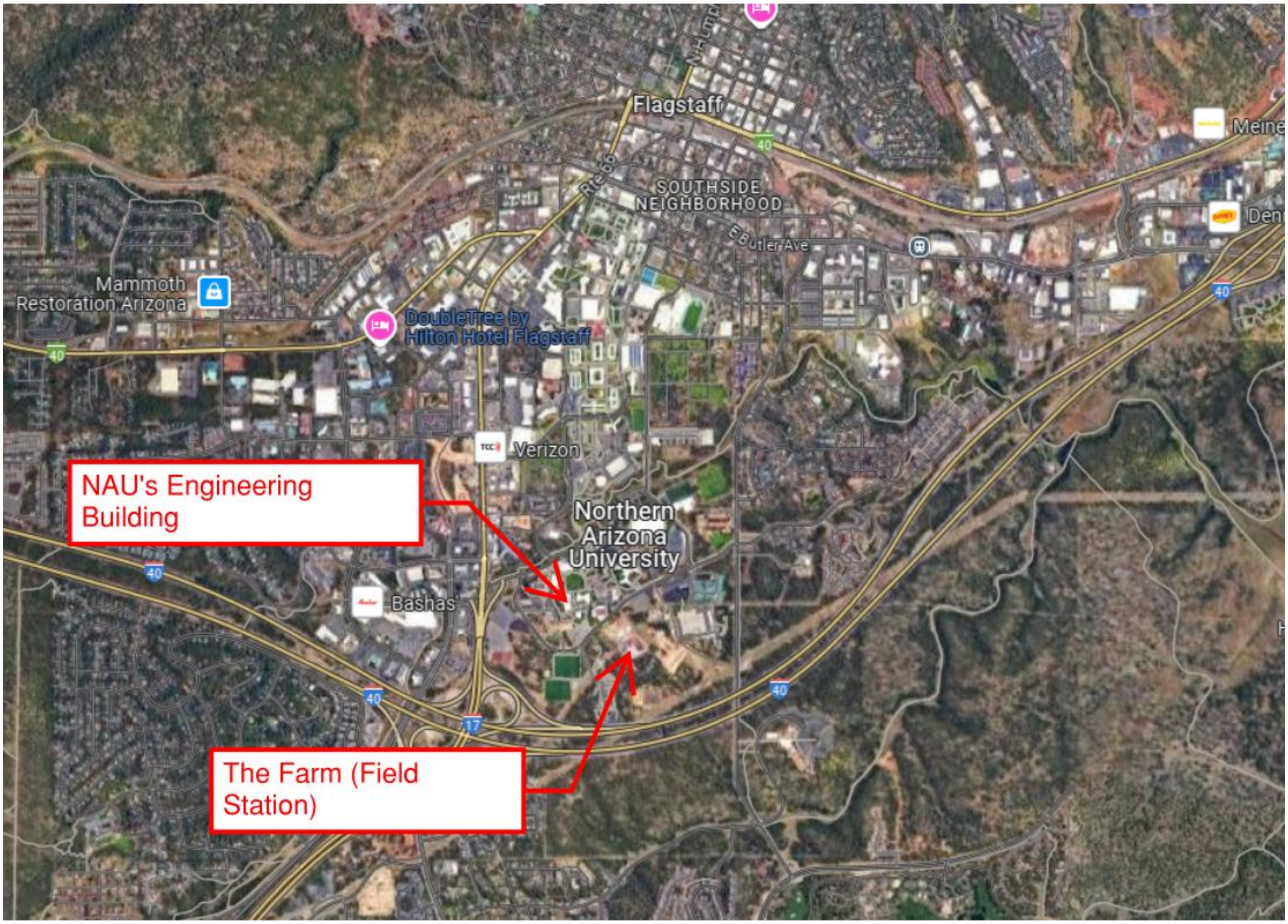
Appendices

Appendix A: Location Map



Appendix B: Vicinity Map

Appendix C: Staffing

Tasks	SENG	STENG	SUPR	SAFT	INT	TOTAL
1. Background Research	10	25	5	5	2	47
1.1 Competition Rules	2	5	3	2	1	13
1.2 Material Research	2	5	2	1	1	11
1.3 National Design Specification (NDS)	2	5	0	1	0	8
1.4 Special Design Provisions for Wind and Seismic (SDPWS)	2	5	0	1	0	8
1.5 MathCAD	2	5	0	0	0	7
2. Preliminary Design	30	55	15	15	2	117
2.1 Timber Selection	12	20	6	6	0	44
2.2 Initial Design Decisions	12	20	6	6	0	44
2.3 Design Matrix	6	15	3	3	2	29
3. Design and Analysis	15	18	0	2	4	39
3.1 Gravity Loads	8	9	0	1	2	20
3.2 Lateral Loads	7	9	0	1	2	19
4. Roof Design	15	50	5	5	4	79
4.1 Roof Gravity Strength Design	3	2	1	1	1	8
4.2 Diaphragm Design	3	2	1	1	1	8
4.2.1 Seismic Load	0	4	0	0	0	4
4.2.2 Strength Design	0	4	0	0	0	4
4.2.3 Serviceability	0	4	0	0	0	4
4.3 Chord Design	3	2	1	1	1	8
4.3.1 Seismic Load	0	4	0	0	0	4
4.3.2 Strength Design	0	4	0	0	0	4
4.3.3 Serviceability	0	4	0	0	0	4
4.4 Collector Design	3	2	1	1	1	8
4.4.1 Seismic Load	0	4	0	0	0	4
4.4.2 Strength Design	0	4	0	0	0	4
4.5 Rafter Tie-Down Design	3	2	1	1	0	7
4.5.1 Wind Uplift Load	0	4	0	0	0	4
4.5.2 Strength Design	0	4	0	0	0	4
5. Wall Design	20	35	5	5	4	69
5.1 Wall Gravity Strength Design	2	4	1	1	1	9
5.2 Wall Lateral Design	2	4	1	1	1	9

5.2.1 Shear Wall Design	1	2	0	0	0	3
5.2.2 Seismic Load	1	1	0	0	0	2
5.2.3 Strength Design	1	1	0	0	0	2
5.2.4 Serviceability	1	2	0	0	0	3
5.3 Hold-Down and Anchor Bolt Design	2	4	1	1	1	9
5.3.1 Overturning Forces	1	2	0	0	0	3
5.3.2 Strength Design	1	1	0	0	0	2
5.4 Floor Design	2	4	1	1	1	9
5.4.1 Gravity Strength	1	2	0	0	0	3
5.4.2 Cantilever Deflection	1	1	0	0	0	2
5.4.3 Lateral Design	1	1	0	0	0	2
5.5 Design Optimization	3	6	1	1	0	11
6. Modeling	10	20	5	0	2	37
6.1 2D Structural Modeling	5	10	2	0	1	18
6.2 3D BIM Modeling	5	10	3	0	1	19
7. Construction	15	30	60	50	20	175
7.1 Material Acquirement and Prefabrication	5	10	20	10	10	55
7.2 Construction Practices	10	20	40	40	10	120
8. Deconstruction Plan	2	2	1	1	4	10
8.1 Disassembly	1	1	1	1	2	6
8.2 Repurposing Plan	1	1	0	0	2	4
9. Investigate Project Impacts	6	7	0	2	2	17
9.1 Environmental Impacts	6	7	0	2	0	15
10. Project Deliverables	20	40	10	10	1	81
10.1 Capstone Deliverables	3	5	1	2	0	11
10.1.1 30% Report Submission	2	4	0	0	0	6
10.1.2 60% Report Submission	2	4	2	0	0	8
10.1.2 90% Report Submission	2	3	2	2	0	9
10.1.4 Final Presentation	1	3	0	0	0	4
10.1.5 Final Report and Website	2	4	0	2	0	8
10.2 Competition Deliverables	2	4	1	2	1	10
10.2.1 Registration and Compliance	0	2	0	0	0	2
10.2.2 Structural Drawings and 3D Modeling	2	3	2	0	0	7
10.2.3 Presentation	1	3	0	0	0	4
10.2.4 Final RFI and Change Order	0	1	0	0	0	1

10.2.5 Visual Aid Creation	1	2	0	0	0	3
10.2.6 Competition Build Day	2	2	2	2	0	8
11. Project Management	10	15	10	5	0	40
1.1 Resource Management	2	2	2	2	0	8
11.2 Schedule Management	2	2	1	0	0	5
11.3 Meetings	0	0	0	0	0	0
11.3.1 Team Meetings	2	1	2	2	0	7
11.3.2 Captain's Meeting	1	1	0	0	0	2
11.3.3 Mentee Meetings	1	1	3	1	0	6
11.3.4 Client Meetings	2	1	2	0	0	5
11.3.5 Technical Advisors Meeting	0	1	0	0	0	1
11.3.6 Grading Instructor Meeting	0	1	0	0	0	1

Appendix D: Gantt Chart