

# FUSION Engineering Project Description

## 2025-2026

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# Project Description

**Name:** Fire Extinguishing Rover

**Purpose:**

To give students the chance to improve their engineering knowledge by developing and building a fire extinguishing rover.

**Project Basis:**

This project maintains a balanced workload for two sub-teams: mechanical and hardware. Mechanical engineers will gain experience in manufacturing and design, while hardware engineers will master Arduino concepts and wiring. Additionally, the project's nature is complemented by a plethora of already available online resources for team members to research and learn from. As the FUSION engineering project has developed over the years, the increased difficulty of this project also facilitates the need for members' skills and knowledge to be challenged to a greater degree.

**Objective of Teams:**

Teams are responsible for designing and constructing a rover to navigate a structured course with obstacles and extinguishing three simulated fire targets using an unlimited amount of distilled water. The design must integrate accurate aiming mechanisms, efficient water management, and reliable navigation systems to ensure all targets are eliminated within the constraints of the challenge. Teams will also participate in Design Reviews and Demo Sessions throughout the Winter and Spring Quarters, while maintaining a detailed Design Binder that documents their design decisions, testing, and fabrication process.

**Team Structure:**

- A maximum of 3 teams that consist of:
  - 2 Project Leads
  - 2 Sub-team leads (*Hardware, Mechanical*)
  - 12 General team members
- Team members will be split by Project Directors based on major and technical experience, unless otherwise provided a reasonable case is provided to be placed in a team. Project Leads and Subteam leads will be selected by preference.

### **General Improvements to FUSION Engineering Project:**

The FUSION Engineering Project will continue to make use of the Design Binder, alongside the regular progress slides for MAE93, to help FEP participants improve their work and documentation habits. Throughout the Winter and Spring Quarter, Teams will participate in Design Reviews and Demo Sessions with Project Directors and Advisors. During these Design Reviews, teams will present their progress, discuss challenges they may be experiencing, and receive feedback. Demo Sessions will have teams demonstrate their robots' functionality. Teams will also formally present their work and robot at FUSION's annual FUSIONCon in the spring, thereby enhancing in their public speaking and presentation skills. In addition, the difficulty of the project has increased this year for the purpose of pushing our members to collaborate and strengthen their creativity and technical expertise. New concepts they will be working with through this process include wireless communication, transmitters, fluid mechanics, electronics, and challenging their creativity.

Due to the specialized nature of creating this rover, FEP participants will have access to a Project Curriculum that details general knowledge for the mechanical and hardware aspects of the project, as well as key concepts to create a rover, including the water pump mechanism. This curriculum is meant to guide members along during the lifetime of the project. Members will be expected to follow along with the curriculum to ensure the quality of their contributions to their project.

## Competition Description

The Fire Extinguishing Rover Competition challenges student teams to design and build a mobile robotic system capable of identifying and extinguishing three “fire” targets located on a structured course. These targets are typically simulated using visual indicators rather than real flames.

The rover must use only distilled water, provided in limited quantities per round, to extinguish the targets. This constraint emphasizes efficient design and precision in targeting.

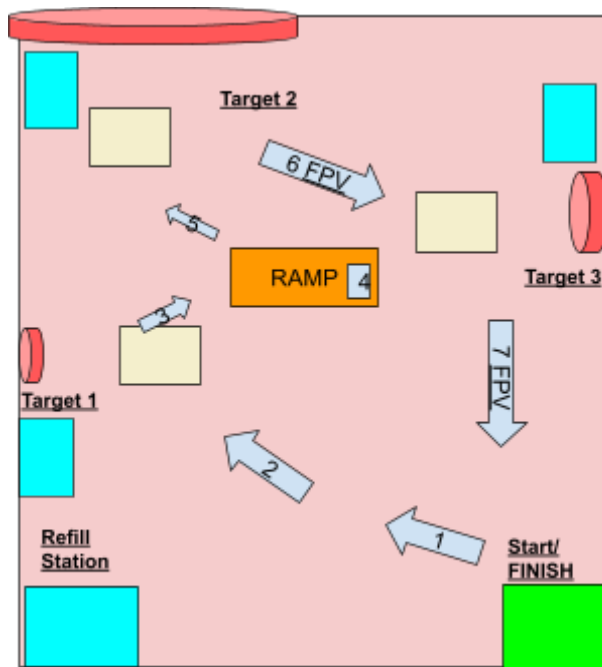
The competition course includes various environmental elements such as boundary walls, obstacles, and uneven target placement to simulate real-world navigation challenges. While the level of autonomy is flexible, teams are encouraged to implement vision-driven navigation, such as camera integration. Manual, semi-autonomous, and fully autonomous rovers are typically all allowed.

Successful designs will feature a well-integrated water pump mechanism, intelligent control systems, and reliable navigation. Judging will focus on: target elimination, time efficiency, water conservation, and the quality of engineering design.

The project requires multidisciplinary collaboration across mechanical and hardware components, making it an educational design challenge.

*The Co-Project Directors will record the ranking of each team based on the time taken to complete the challenge (this will factor into their placing in the overall competition).*

# Competition Field



**NOTE:** The amount and placement of Zones and targets are subject to change.

## Zone Dimensions:

- 24'L x 24'W

## Obstacle Dimensions:

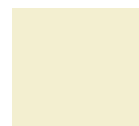
- Ramp (wood):
  - 40" L x 30" W
  - 20\* Degree Incline
  - Wood
- Obstacles (physical objects):
  - Largest: 12" x 12"

## Target Dimensions:

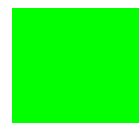
- Target 1:
  - [4.8 in Diameter](#)
  - Height: 3 ft
  - Distance: 30 inches from the front-most point of rover to the target face.
- Target 2 (Surface Area Test):
  - Poster Paper 4 ft x 2 ft
  - Height: 2ft
  - Distance: Fixed at 24 in. from the front-most point of rover
- Target 3 (Camera Only):
  - [4.0in Diameter](#)
  - Height: 3ft
  - Distance: Fixed at 30 inches from the front-most point of the rover to the target face.

## Rover Max Dimensions:

- Base Rover around 24" x 18" x 18"



- **Target Zone(s)**



- **Start Zone**



- **Refill Station(s)**

## Target Descriptions

The rover will interact with three distinct targets designed to evaluate accuracy, dispersion, and camera-only operation. For all targets, the rover must be fully stationary while dispensing water. Movement during active spraying will result in a 5-second time penalty per occurrence. A firing line will be marked for each target and corresponds to the listed placement distance. The rover must remain fully behind this line while dispensing water. Spraying is defined as any instance in which water exits the nozzle. Exceeding or missing water allocation targets will deduct points in the final scoring.

### Target 1 – Stationary Accuracy Target

- Dimensions:
  - Diameter: 4.8 in
  - Height: 3 ft
- Placement Distance: 30in from the front-most point of the rover to the target face
- Water Allocation: 150 mL
- Description: Successful interaction is defined by depositing 150 mL of water into a horizontally mounted funnel-shaped target that directs water into a collection container. Water that passes through the funnel and remains in the collection container will be counted toward the total volume.

### Target 2 – Surface Area (Dispersion) Test

- Dimensions:
  - Poster paper size: 4 ft × 2 ft
  - Height: 3 ft
- Placement Distance: Fixed at 24 inches from the front-most point of the rover to the target face.
- Water Allocation: Variable (within rover capacity)
- Description: This target evaluates the spread and dispersion of water across a surface. The target consists of poster paper mounted vertically (firewall). The poster paper will be pre-marked with a 6-inch by 6-inch grid. A grid square is counted as covered if visible wetting is present within the square after spraying. Scoring is based on the total number of grid squares covered. Target 2 is considered complete after **20 seconds in the zone.**
- **LEAVING THIS ZONE MUST REQUIRE ONLY THE USE OF A FPV CAMERA.**
  - **DRIVER MUST NOT BE FACING THE COMPETITION FIELD AFTER LEAVING ZONE 2**

### **Target 3 – FPV Camera-Only Target**

- Dimensions:
  - Diameter: 4.0 in
  - Height: 3 ft
- Placement Distance: Fixed at 30 inches from the front-most point of the rover to the target face.
- Water Allocation: 200 mL
- Description: This target is designed to test operation using only the FPV camera feed, without direct line-of-sight. Operators must rely exclusively on the FPV camera feed during engagement of Target 3. Direct visual line of sight to the rover or target is not permitted. The rover must accurately deliver 200 mL of water into a small-diameter target, emphasizing camera alignment, depth perception, and operator control.

### **Water Usage and Refilling Rules**

- Each team is limited to a maximum total water usage of unlimited water during the competition.
- Refill stations will be provided on the competition field.
- Teams may access the refill stations at any time during a run.
- Refill stations may only be used to redistribute or reposition the team's initial water supply.

## Rules and Scoring

### Rules for Competition:

#### ***Challenge 1: Course Navigation & Fire Extinguishing***

- The rover must navigate the designed course to reach three separate “fire” targets.
- Each target must be considered extinguished before proceeding to the next, based on its specific requirements.
- Teams must carefully manage their limited water supply to put out all three fires successfully.
- “Comming” is allowed to make sure you are hitting water requirements.
- Navigation Constraints:
  - Some course obstacles, such as walls or barriers, are fixed and cannot be moved.  
**Any contact with a restricted obstacle, like knocking over walls, will result in a point penalty for each violation.** Rover should have a way to avoid obstacles

#### ***Challenge 2: Fabrication & Design Evaluation***

- Teams can retain points if the fabrication deliverables are met. This includes the following criteria:
  - Consistent engineering drawings and FEA analysis.
  - Minimal utilization of mechanical materials.
  - Coherent application of robot design restraints.
- Scoring Opportunities:
  - Additional points awarded for incorporating extra components that improve performance
  - Use of alternative materials (excluding 3D printing).
- Pump & Mechanism
  - Pump design scored on strength, water-shooting distance, compactness, and integration.
  - Use of compliant mechanisms to reduce part count and improve durability will be recognized.

### Scoring:

- Total Ranking: Competition 60%, FUSIONcon<sup>1</sup> 40%
- The *competition score* for each team will be calculated using the sum of the placings from the two challenges; the higher the score, the better.
- The *presentation* will be evaluated by a panel of judges using a standardized scoring rubric provided by the Project Directors and Advisors.

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<sup>1</sup>The presentation slide show and poster for FUSIONcon must be submitted to the Co-Project Directors **48 hours before FUSIONCon**.

## **Robot Design Constraints**

- The robot must be ground-based
- Capable of independent navigation without any external physical assistance during operation
- The water delivery system must be mounted on the rover.
- Spraying while in motion is permitted during testing and development, but is not allowed during official competition runs.
- Multiple targets may be addressed in a single run, but water must be managed strategically
- Rover must include a first-person view camera system using Arduino or ESP32.
- Cost: \$~750
- Max. Starting Dimensions: 1.5 ft x 1.5 ft
- Max. Starting Height: 1.5 ft
- Max. Weight (w/o water): 20 lbs

***NOTE: Robot Design Constraints are subject to change.***

## **Robot Design Challenges**

**General Improvements:**

## Scheduling

Items highlighted in [blue](#) text are suggested milestones to be achieved; specific scheduling information can be found [here](#).

<b>WINTER QUARTER</b>	
<b>Week 1</b>	<ul style="list-style-type: none"> <li>● Project begins</li> </ul>
<b>Week 2</b>	<ul style="list-style-type: none"> <li>● <a href="#">Frame Design and Basic Components</a> <ul style="list-style-type: none"> <li>○ Research the dimensions of your rover.</li> <li>○ Start with simple 2D sketches for the frame, then extrude them into 3D.</li> <li>○ Create motor mounts, pump mounts, wheels, drivetrain, etc.</li> </ul> </li> <li>● MAE93 Progress Slides Due</li> </ul>
<b>Week 3</b>	<ul style="list-style-type: none"> <li>● <b>Deliverables:</b> <ul style="list-style-type: none"> <li>○ 3D Modeled Parts of the Rover</li> </ul> </li> </ul>
<b>Week 4</b>	<ul style="list-style-type: none"> <li>● <a href="#">Pump Mechanism Design</a> <ul style="list-style-type: none"> <li>○ Sketch and model the parts of the pump mechanism: pump, nozzle, and any other moving parts</li> <li>○ Design a working 3D model of the movable parts in SolidWorks, like hinges, brackets, or actuators, for controlled water release</li> </ul> </li> <li>● MAE93 Progress Slides Due</li> </ul>
<b>Week 5</b>	
<b>Week 6</b>	<ul style="list-style-type: none"> <li>● <a href="#">Manufacturing of parts begins</a> <ul style="list-style-type: none"> <li>○ 3-D Parts are printed out and are presentable</li> <li>○ Make sure each part fits within the assembly</li> </ul> </li> <li>● MAE93 Progress Slides Due</li> </ul>
<b>Week 7</b>	<ul style="list-style-type: none"> <li>● Continue manufacturing</li> <li>● Begin wire and motor testing</li> </ul>
<b>Week 8</b>	<ul style="list-style-type: none"> <li>● MAE93 Progress Slides Due</li> <li>● Electronics Integration</li> <li>● <i>External</i> Design Review (FASAE) <ul style="list-style-type: none"> <li>○ Show informal design</li> <li>○ Show full TinkerCAD/Solidworks</li> <li>○ Show full CAD model</li> </ul> </li> </ul>

<b>Week 9</b>	<ul style="list-style-type: none"> <li>● Physical testing</li> </ul>
<b>Week 10</b>	<ul style="list-style-type: none"> <li>● MAE93 Reflection, Peer Review, and Progress Slides Due</li> <li>● <i>External</i> Design Review (SOE) <ul style="list-style-type: none"> <li>○ Show Revised Design</li> <li>○ Show Hardware/Mechanical Implementations</li> </ul> </li> <li>● <a href="#">Show the full assembly physically</a></li> </ul>

<b>SPRING QUARTER</b>	
<b>Week 1</b>	<ul style="list-style-type: none"> <li>● Debugging and system check</li> <li>● Testing schedule</li> </ul>
<b>Week 2</b>	<ul style="list-style-type: none"> <li>● MAE93 Progress Slides Due</li> </ul>
<b>Week 3</b>	<ul style="list-style-type: none"> <li>● Finalize driving + spraying mechanisms</li> </ul>
<b>Week 4</b>	<ul style="list-style-type: none"> <li>● MAE93 Progress Slides Due</li> <li>● <i>Tentative</i> Design Review <ul style="list-style-type: none"> <li>○ Present a rover demo</li> <li>○ Functional mobility + pumping system</li> </ul> </li> </ul>
<b>Week 5</b>	<ul style="list-style-type: none"> <li>● Changes to the rover based on Feedback</li> </ul>
<b>Week 6</b>	<ul style="list-style-type: none"> <li>● Demo Day: Testing on a physical competition field</li> </ul>
<b>Week 7</b>	<ul style="list-style-type: none"> <li>● Demo Day: Testing on a physical competition field</li> </ul>
<b>Week 8</b>	<ul style="list-style-type: none"> <li>● Competition Day May 16th: Official Scoring on a physical competition field</li> <li>● Project showcase &amp; expo at FUSIONCon - May 17. 2026</li> </ul>
<b>Week 9</b>	
<b>Week 10</b>	<ul style="list-style-type: none"> <li>● MAE93 Reflection and Peer Review Due</li> </ul>

## Bill of Materials (Estimated Example)

Materials	Supplier/ Vendor	Unit Price	Quantity	Reasoning for Purchase	Total Price
Arduino Uno Rev3	<a href="#">Amazon</a>	\$29.00	1	Acts as the main microcontroller to control actuators and handle input/output logic.	\$29.00
Greartisan DC 12V 20RPM Gear Motor	<a href="#">Amazon</a>	\$15.99	4	Provides high-torque, low-speed motion for mobile base movement and mechanical actuation.	\$~63.96
H-Bridge Motor Driver	<a href="#">Amazon</a>	\$9.99	1	Enables bidirectional control of DC motors. Allows PWM-based speed control/motor direction switching.	\$9.99
A4988 Stepper Driver	<a href="#">Amazon</a>	\$7.99	1	Controls stepper motors with microstepping for precise movement.	\$7.99
3S LiPo Battery	<a href="#">Amazon</a>	\$25.99	1	Primary power supply for motors and onboard systems.	\$25.99
LiPo Battery Charger	<a href="#">Amazon</a>	\$12.99	1	Safely recharges LiPo batteries, preventing overcharge or fire hazards.	\$12.99
Raspberry Pi 4	<a href="#">Amazon</a>	\$66.09	1	Main onboard computer for streaming control and processing.	\$66.09

Camera Module v2	<a href="#">Amazon</a>	\$13.99	1	Provides FPV video feed.	\$13.99
RC Transmitter + Receiver	<a href="#">Amazon</a>	\$54.99	1	Wireless control of the rover's movement, camera pan/tilt, and water nozzle.	\$54.99
XT60 Connector	<a href="#">Amazon</a>	\$8.99	1	Robust power connector for high-current LiPo connections	\$8.99
Power Distribution Board	<a href="#">Amazon</a>	\$18.57	1	Distributes power from the battery to all the essential components, especially the motors and ESCs.	\$18.57
Aubig 12V Brushless DC Water Pump	<a href="#">Amazon</a>	\$38.99	1	The main actuator for extinguishing fires is a pressurized water stream.	\$38.99
Relay Module	<a href="#">Amazon</a>	\$6.99	1	On/Off switch for water pump.	\$6.99
Multimeter	<a href="#">Amazon</a>	\$29.87	1	Used for measuring voltage, current, and resistance during assembly and testing to ensure proper electrical connections.	\$29.87
Voltage Regulator	<a href="#">Amazon</a>	\$7.99	1	Ensures enough current is split among the motors to adequately drive the Rover.	\$7.99
PWM Headers/Connectors	<a href="#">Amazon</a>	\$9.29	1	Enable clean, modular signal routing for servo and motor connections.	\$9.29

Pan/Tilt Mount	<a href="#">Amazon</a>	\$13.99	1	Directional pan/tilt movement of the camera and nozzle	\$13.99
Stepper Motor Driver	<a href="#">Amazon</a>	\$5.89	1	Required for the additional servo control channels.	\$5.89
Screws	<a href="#">Amazon</a>	\$20.99	1	Mounting components onto the rover.	\$20.99
Tubing	<a href="#">Amazon</a>	\$6.88	1	Tubing to connect the reservoir to the water pump and spray head.	\$6.88
Spray Head	<a href="#">Amazon</a>	\$8.49	1	Spray head to dispense the water onto the target.	\$8.49
Wheels	<a href="#">Amazon</a>	\$16.99	1	Wheels allow the rover mobility.	\$16.99
Breadboard	<a href="#">Amazon</a>	\$9.99	1	Prototyping and wire routing.	\$9.99
Wood	X	0	1		
Structural Materials	-	-	-		\$50
3D printing costs	-	-	-		\$100
Miscellaneous costs	-	-	-		\$100

**Total: \$728.60**