Design 3 Group project

A novel design of a wildfire fighting device

List of group members:

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Teppei Goto

Norbert Bacsko

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Design 1: Harry Byrne – 9855819

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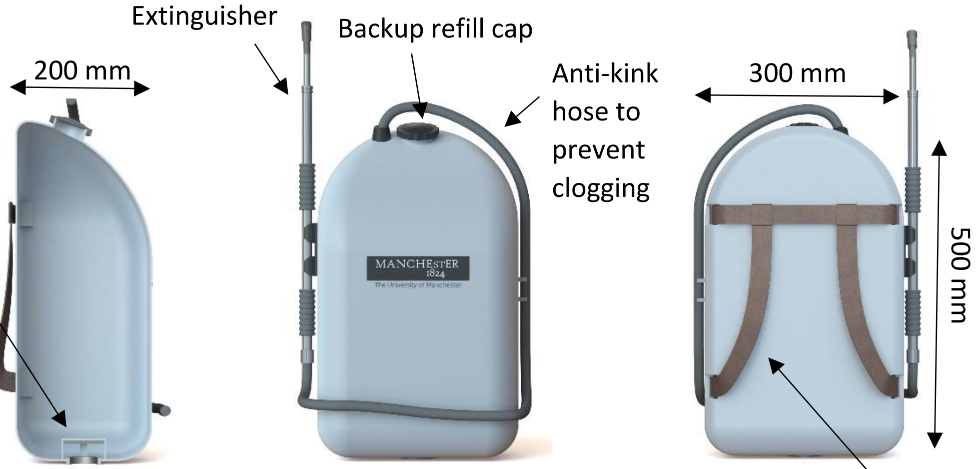


Figure 1.2: Front, back and section view of the tank assembly

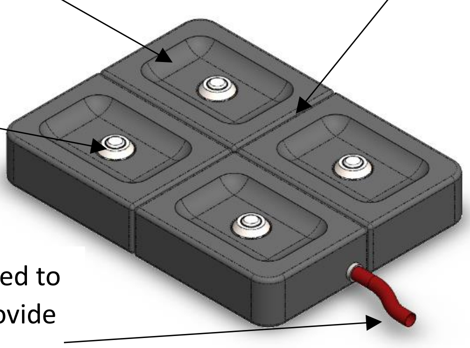
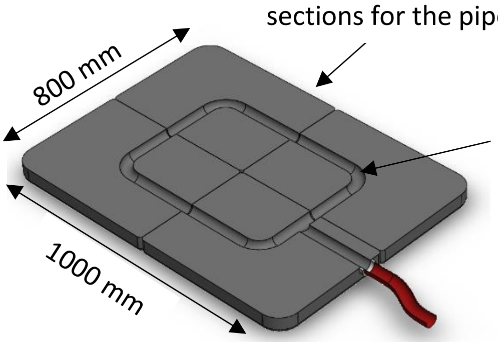


Figure 1.3: View of the base assembly



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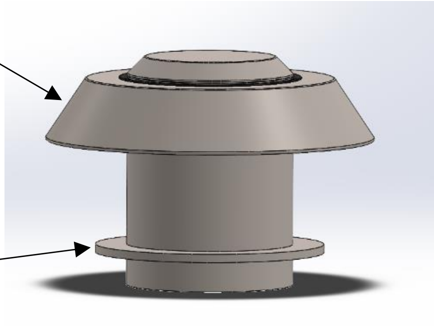

Figure 1.5: View of the nozzle assembly with the release up

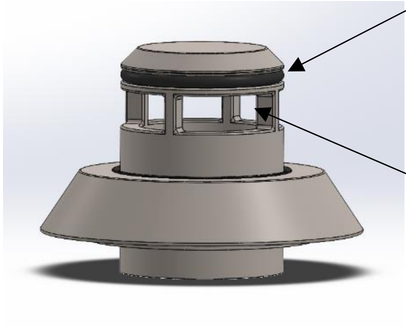

Figure 1.6: View of the nozzle assembly with the release down

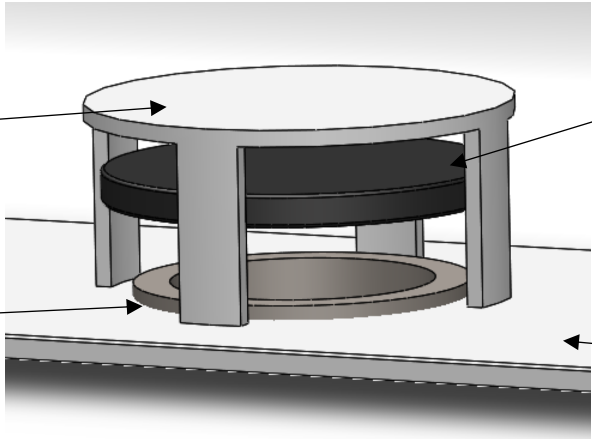

Figure 1.7: View of the connection from inside the tank

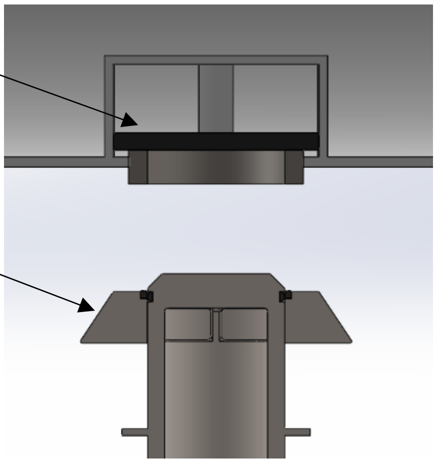

Figure 1.8: View of the connection inside the tank before contacting the nozzle

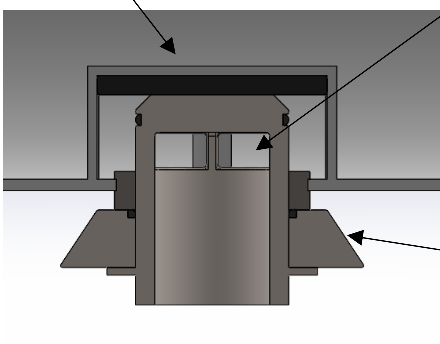

Figure 1.9: View of the connection inside the tank after contacting the nozzle

Section 1(b): Description of the design and its operation

The present work outlines a design augmentation to an existing rigid tank extinguisher backpack, the augmentation being a tank/reservoir docking system that allows rapid automatic refill [1]. An extinguisher backpack is used by field personnel to clear up small fires, and is typically hand filled by tap via a screw on cap [2]. With the proposed augmentation up to four docked tanks can be filled at the same time on lightweight easily moved fill station, a docked tank being bottom filled via a magnetically sealed hole. It is predicted that the proposed augmentation will save time and effort, and allow much more efficient usage of equipment and personnel. The deployable fill station can be carried through rough terrain to provide a forward fill point. In addition, the tank autofill allows a short respite for weary workers.

Assembly and operation:

- The base assembly can be carried on foot to the desired location
- Each component of the assembly is slotted together using the locators on the inner sides of each section
- The base assembly is then connected to the pump hose
- To fill a tank, push it onto one of the four nozzles, guided by the location grooves
- The nozzle will displace the magnetic cap unsealing the underside of the tank, and with the nozzle release lowered, water will flow (ca. 20 L/min)
- The fill station will then dispense a preprogramed amount of water (ca. 10 – 30 L)
- When the tank is removed the fill station, the magnetic cap will reseal the bottom ready for use
- Repeat filling process as required, then disassemble and move to the next location.

Section 2: Design reflection and identification of possible problem areas of the concept for further development

As with any piece of industrial equipment, abusive handling by the operator must be assumed, in addition, even without abuse, the equipment will be carried and used in notionally rough and tense situations. While the current design has a level of toughness, it does have some small, possibly vulnerable mechanical parts, damage or even failure of said parts is identified as a possible problem area. In an effort to maximise operational toughness, the reduction, elimination or redesign of said parts, and/or the possible use of alternative materials for manufacture is proposed for design improvement.

While the current design is simple to assemble and operate, with more thought, it could likely be further simplified and improved, for example, a better method for connecting the base sections together would certainly ease fill station assembly and shorten equipment implementation time. In addition, the grooves in the fill station base, used to locate a tank during refill, could also be improved or redesigned to afford a more secure connection.

Finally, and perhaps most importantly, for uniform fill of two or more docked tanks, the layout of the water distribution system could be optimized, a centralized reservoir in the fill station base with radial water channels to each fill nozzle would likely produce a more balanced water conveyance.

Design 2: Teppei Goto 10496061

<u>Section 1(a): Presentation of the concept using illustrations</u>

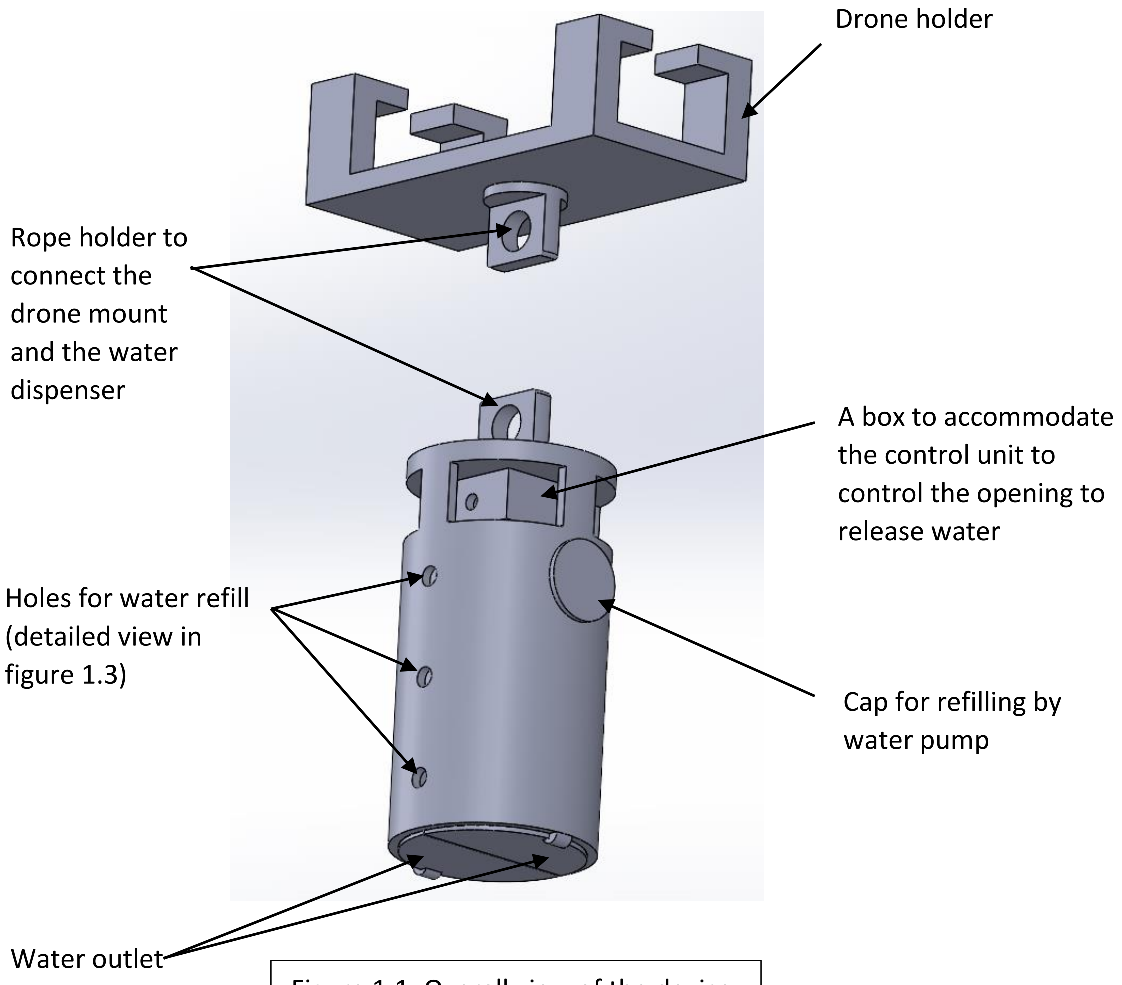

Figure 1.1: Overall view of the device

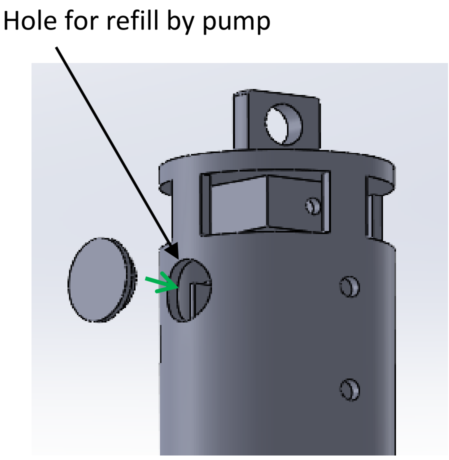

Figure 1.2: Cap removed for refill

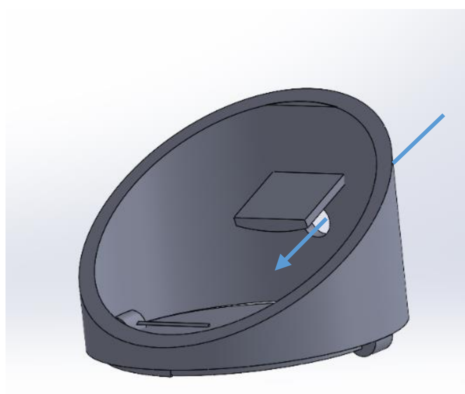

Figure 1.3: Section view of the refill mechanism

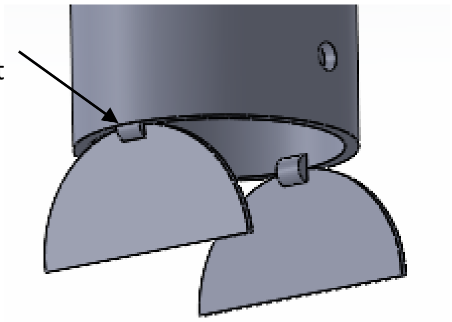

Figure 1.4: Detailed view of the water outlet

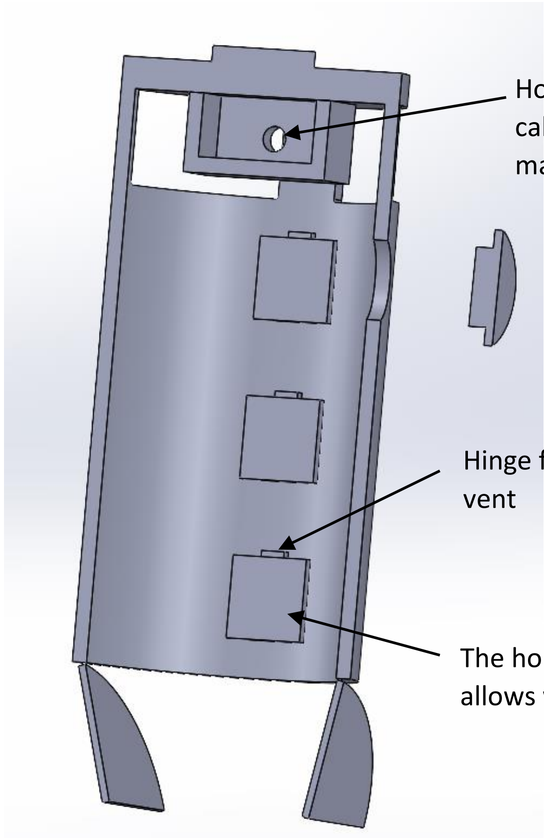

Figure 1.5: Section view of the water dispenser

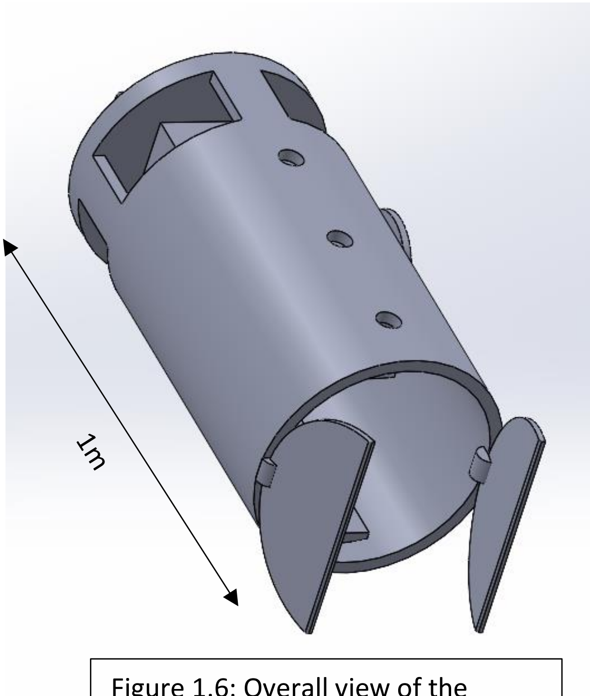

Figure 1.6: Overall view of the dispenser from the bottom

Figure 1.7: The Griff 300 (GRIFF Aviation, 2021)

Section 1(b): Description of the design and its operation

This device consists of two main components which are the drone holder and the water dispenser. This design must be used with a drone called The Griff 300 (GRIFF Aviation, 2021) showin in fig 1.7. The drone and the device are transportable by a lorry as the drone is about $1.2m \times 3.4m \times 0.6m$ (Poljak, 2021) and the device is no more than 2m in length. When the set up is transported to where the drone is needed, the drone holder is attached to the drone's body. The water dispenser is attached via a rope tightened to the rope holders on the mount and the dispenser. The rope can be used with carabiners on either end for quicker preparation. The design of the drone mount can be altered easily depending on the type of drones used.

The drone and the water outlet are remotely controlled and when it reaches where the fire is, and water inside the dispenser is dropped by opening the outlet illustrated in fig 1.4. The outlet is controlled by the operation unit fitted on the ceiling of the dispenser. The hole allows signals from the remote to be received by the unit as well as for cable managements.

The device can refill water in two different ways. Either by pumping water through the hole illustrated in fig 1.2 or by submerging the dispenser in water. The weight of the dispenser is enough to sink to the first holes on the wall, then it allows water in as illustrated in fig 1.3. There are covers on the inside for each hole and these only allow water to get in. Thus, the second refilling method does not require additional energy.

Section 2: Design reflection and identification of possible problem areas of the concept for further development

Due to limited allowance for weight that can be carried, the amount of water that can be transported at a time is lower compared to other similar methods like airplanes or helicopters. However, more than one drone can be utilised to continuously supply water. Additionally, drones are also limited by the short operation time compared to other methods. Direct solution to this would be to swap batteries after a few trips or take the set up as close as possible to the site where the device is needed.

Materials that will be used to manufacture the device must be considered carefully as they need to be light enough to be carried by the drone, but they must withstand harsh conditions the device may face such as extreme temperatures and smoke. Thus, the overall set up could be expensive unless mass produced. The complex shape of the dispenser would also increase the cost of manufacturing. By using the technology of 3D printing, biodegradable material can be used to manufacture the dispenser. However, the cost would still be high for mass production. The mechanism of how the openings could be optimised as the placement of the control unit isn't ideal. It would be more beneficial if it was moved closer to the water outlet. The device would become more effective and viable option when there are more options for drones that have high load capacity.

Design 3: Norbert Bacsko 10344631

Section 1(a): Presentation of the concept using illustrations

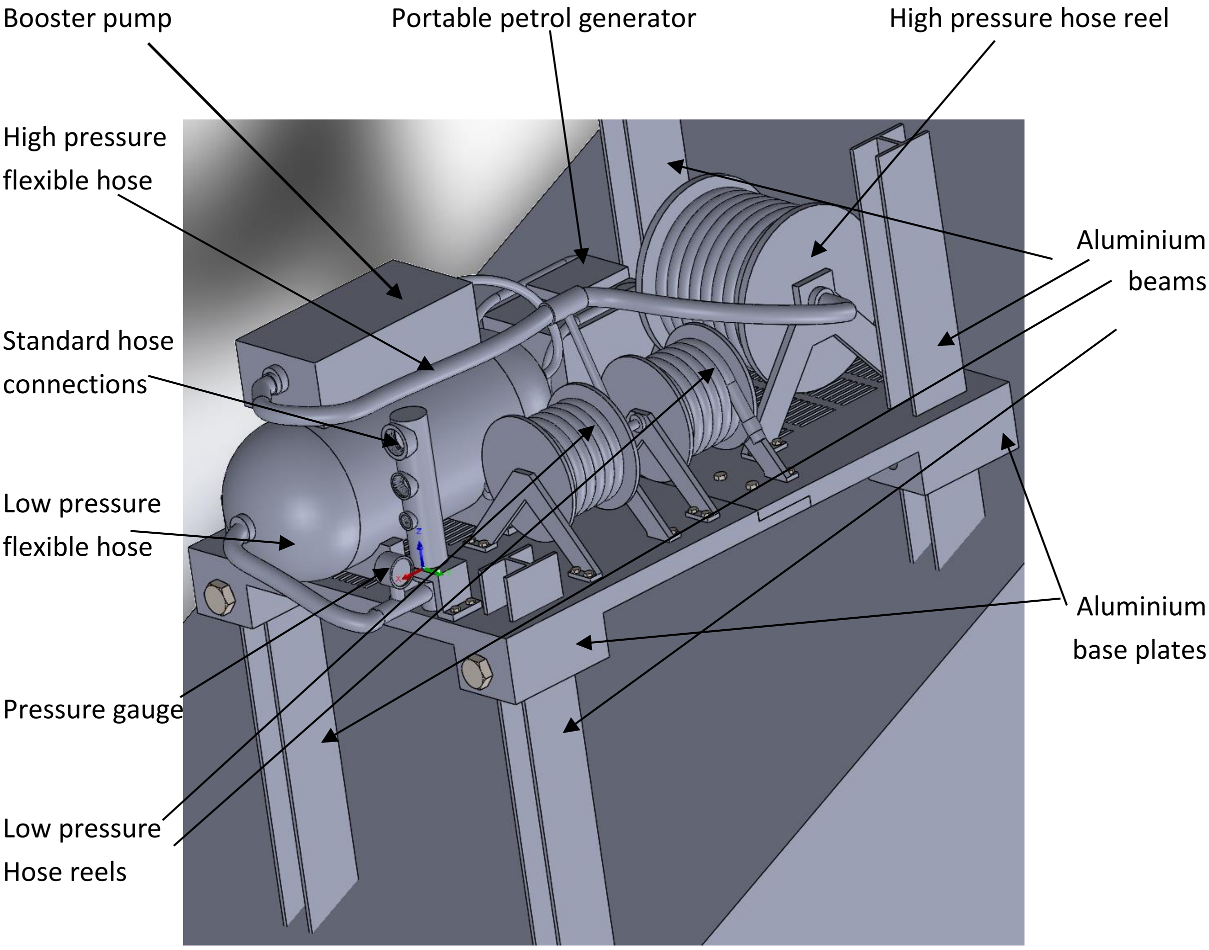

Figure 1: Overall design components

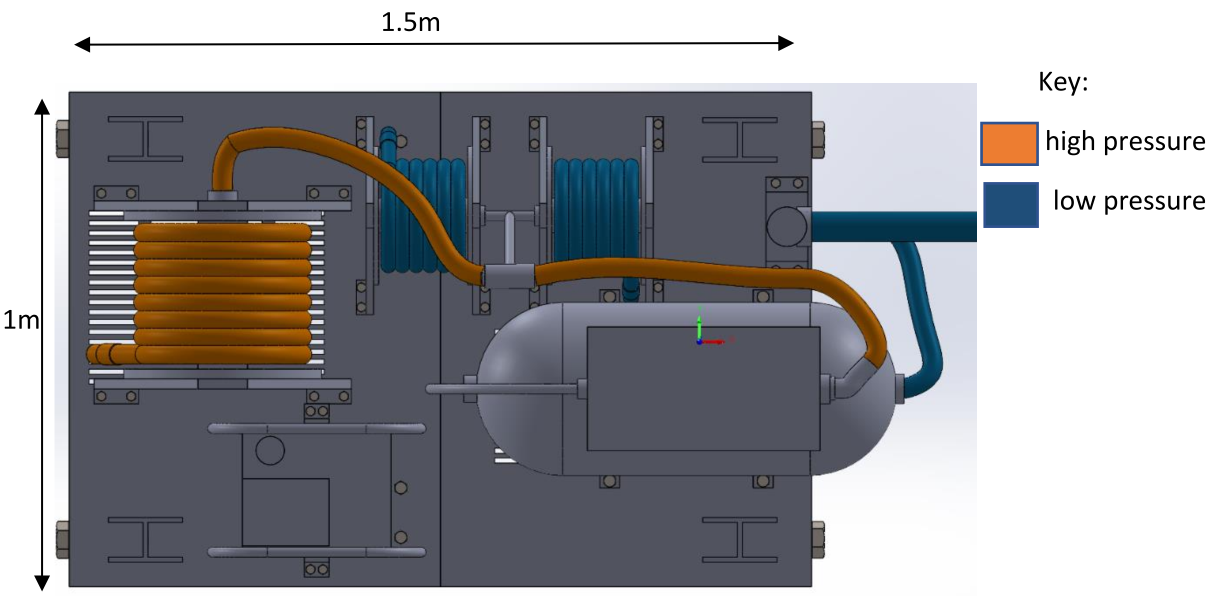

Figure 2: General dimensions/operation procedure

Four holes dug into ground at desired site with beams placed inside

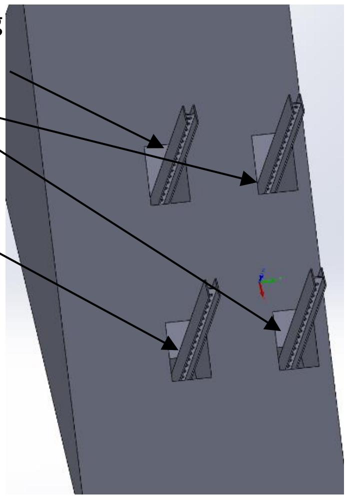

Figure 3: First step of on-site assembly

Secured horizontal platform using bolts through holes in the beams

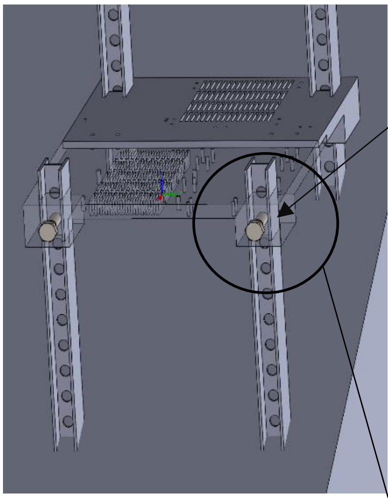

Figure 4: Second step of assembly

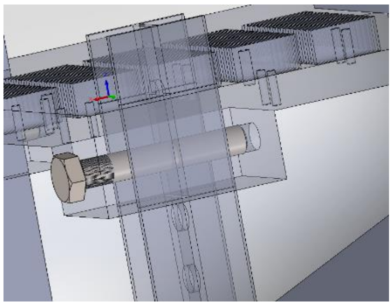

Figure 5: detailed view of simple adjustable securing method

All required components mounted using standard screws and hoses secured in place

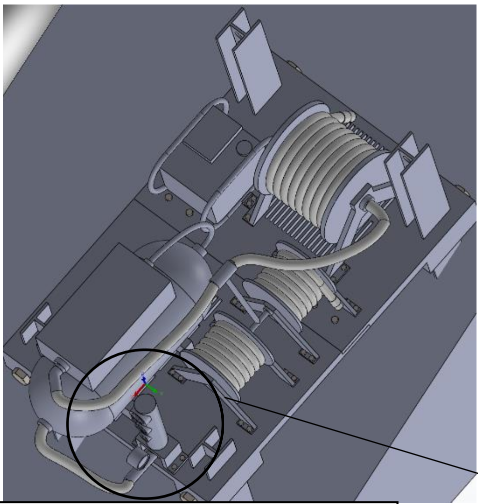

Figure 6: final step of assembly

Each inlet has a valve and only the connected one opens

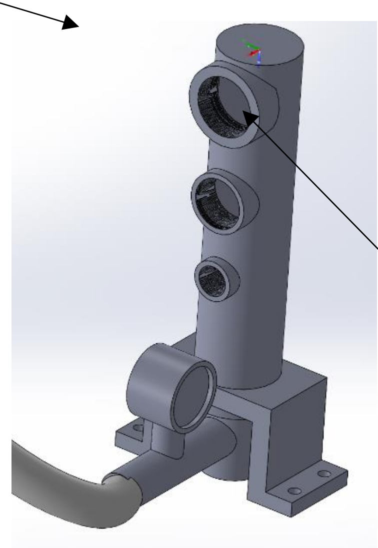

Figure 7: detailed view of custom Multiple standard hose connections

Multiple units chained together

Multiple skid units , fire trucks or a reservoir as source of water

“Line of fire”

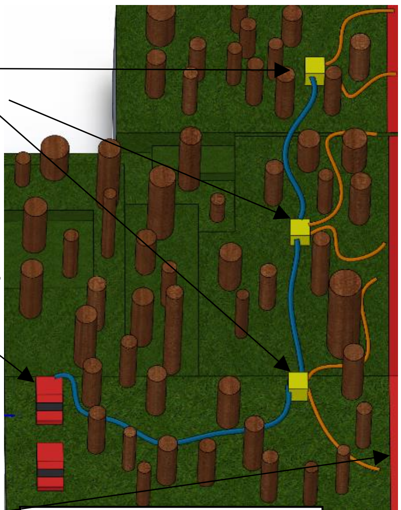

Figure 8: Expected usage case for system

Section 1(b): Description of the design and its operation

Currently existing solutions such as skid units for pickup trucks [1,2], fire trucks [3] and water trucks all suffer from only reaching relatively traversable areas while also having limited range, area covered and head depending on their model thus the goal is to improve their capabilities in this regard without the need for very expensive modifications or parts. The system is comprised of assemble on site units that can be carried on foot to pre-planned key locations piece by piece, assembled and then chained together as required with each of them containing the necessary pressure management and boosting components (figure1). Each unit would take about 3 hours to set up and then up to two firemen can use each unit as a constant source of water to maintain long term firefighting capabilities. They can an act as both an extension point so that larger areas can be serviced more effectively, and a booster point so that higher elevations can be reached and defended (Figure 8). It is compatible with many standard hoses and multiple off shelf components such as pumps so it can be optimised for multiple areas or scenarios similarly to how some custom skid units are made [4].

<u>A rough outline of the transport/operation process</u>

- Transported to site on a pickup-truck or trailer
- Crew digs the four required holes at pre-planned locations
- Two or more firefighters carry each component to desired location
- After securing the beams, rest of the components are assembled within the given timeframe
- Connect all the flexible hoses and start the system
- To ensure continuous operation 2 trucks are required where one stays on site and the other refills during downtime
- After fire is out, disassemble the system in reverse order and transport to next required site

Section 2: Design reflection and identification of possible problem areas of the concept for further development

The overall mobility of the system after deployment is a major concern as in case the fire spreads quicker than can be extinguished all the equipment needs to be left behind and may get destroyed or damaged in the fire, this could however be easily mitigated by including fire-proof cover blankets in the package, a complete solution would however require another separate custom designed cover housing for example. Leading onto the cost and complexity of each kit, as if simply acquiring a more powerful main pump and inexpensive hose splitters would cost less than the proposed system then there would be no tangible benefit for all the extra set-up time, training and extra risks associated.

Furthermore, the design and manufacture of the pressure management system and custom components could prove very challenging especially with the given aim of versatility. Moreover, to pick a suitable site and ensure that the head of the previous unit is above the required minimum for successful chaining, complex pre-planning would be required which needs to be carried out before deployment increasing response time and may even require software or site analysis which would further increase the complexity. Perhaps the most challenging part would be the need for each relatively heavy part to be carried separately on foot through rough terrain, especially for multiple units over long distances resulting in a heavy physical workload for the firefighters. Currently pulley systems or quad bikes are the two viable solutions each with their extra cost and issues.

Design 4: Michel Pearce-Langton 10364213

Section 1a: Presentation of the concept using illustrations

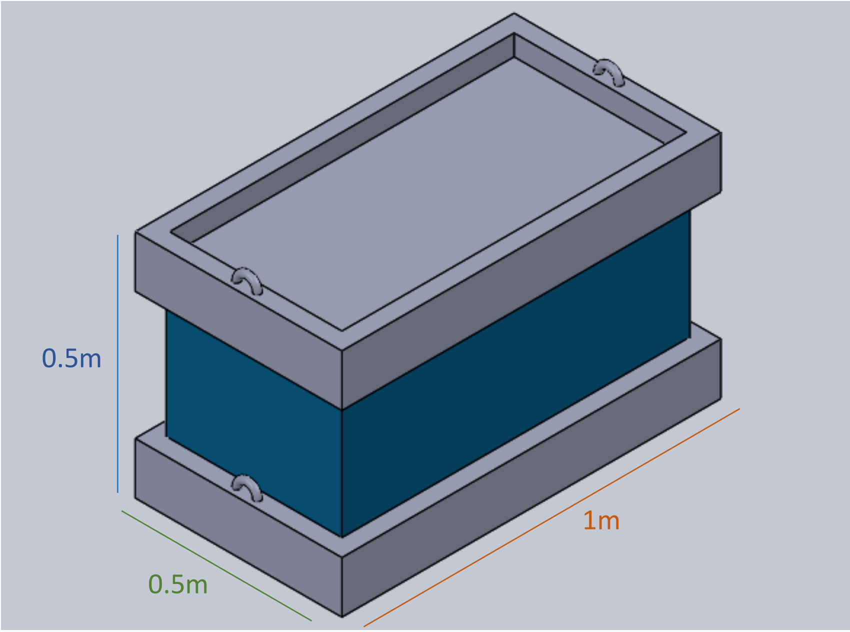

Figure 1 - Fully assembled design of 'transportable water balloon' that can be released from standard cargo planes

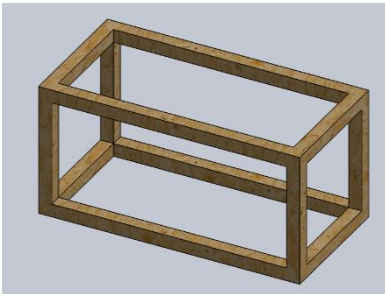

Figure 2 - Inner frame made from biodegradable material

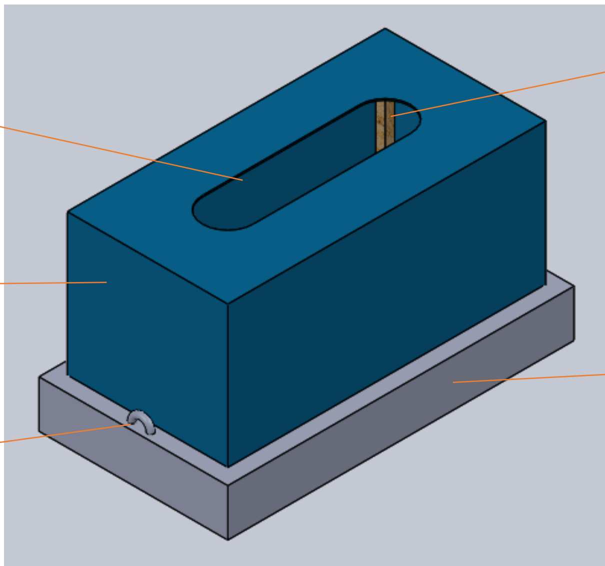

Figure 3 – Balloon ready to be filled with water

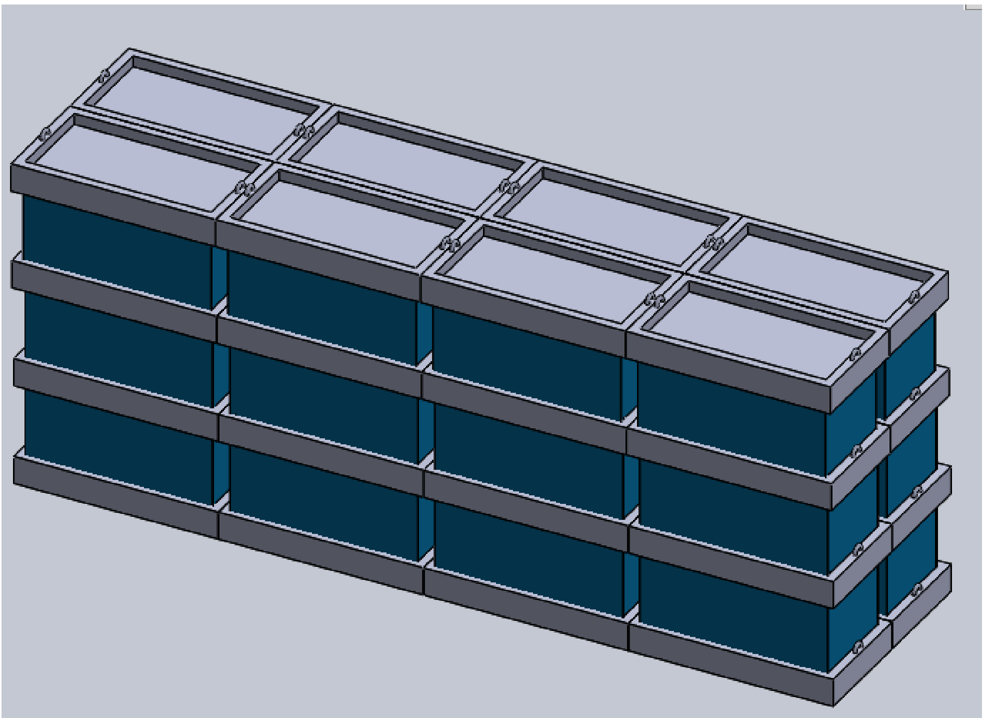

Figure 4 - Stacked transportable water balloon that can be loaded in a cargo plane then released above the forest fire.

Section 1b: Description of the design and its operation

The idea of my design is transportable water balloons. The design is box shaped and stackable meaning it can be loaded on to standard cargo planes with little alteration and doesn't need a specially designed aircraft to carry the water. Biodegradable latex is wrapped round 5 of the 6 sides of an inner biodegradable frame. The container then slides onto the 'separator' to add strength and help maintain the shape. The 6th side that hasn't been covered by the latex is where the water is pumped in and the container is filled. A second separator slides on to cover the open side and a new empty container can be stacked on top. The full stacked containers can then be easily loaded onto standard cargo planes that fly over the wildfire and the containers are released out of the plane mid-flight. The separators all fit on relatively tightly but are not attached therefor when then containers are released the separators slide back off and the water is released. Using calculations to determine the right time to release the containers due to things like wind and speed this water is released and made to artificially rain on the intended area. All the separators are attached to each other and the plane meaning they don't fall with the water containers and can be pulled back into the plane and re used for more trips. As the separators are re used more expensive material that are both strong and light can be used to reduce weight and minimise fuel usage. As specialist planes aren't need for this method and cargo planes are high in abundance, any spare plane can be used to drop water and many flights can take place at once dropping a huge amount of water.

Section 2: Design reflection and identification of possible problem areas of the concept for further development

The first problem area of this concept is the biodegradable inner frame. It is needed to maintain the container's shape and make the containers stackable and easily transportable however it isn't re-useable. This means the material selected needs to be cheap as many will need to be made to put out a wildfire and biodegradable as it will remain wherever it is dropped so will have an environmental impact. Wood would fit these criteria however dropping wood into a wildfire could add further problems as wood is flammable. Also, trees would need to be cut down in order to provide the wood which doesn't seem sustainable when the purpose is to put out wildfires and reduce the deforestation.

Another issue is the weight of the water and the cost of fuel to transport it. The amount of water dropped per flight would need to be maximised to justify fuel emissions which means probably only the larger cargo planes than can carry the most weight can be to reduce environmental impact. The equipment used would need to be as light as possible while maintaining structural integrity. Research would need to be done into the minimum thickness of the inner frame in order to maintain shape while other containers of water are stacked on top and the optimum size of the containers for holding the most water with least material used.

<u>Design 5: Wildfire Sprinkler System Concept – Tait Thompson</u>

Section 1(a): Presentation of Concept Using Illustrations

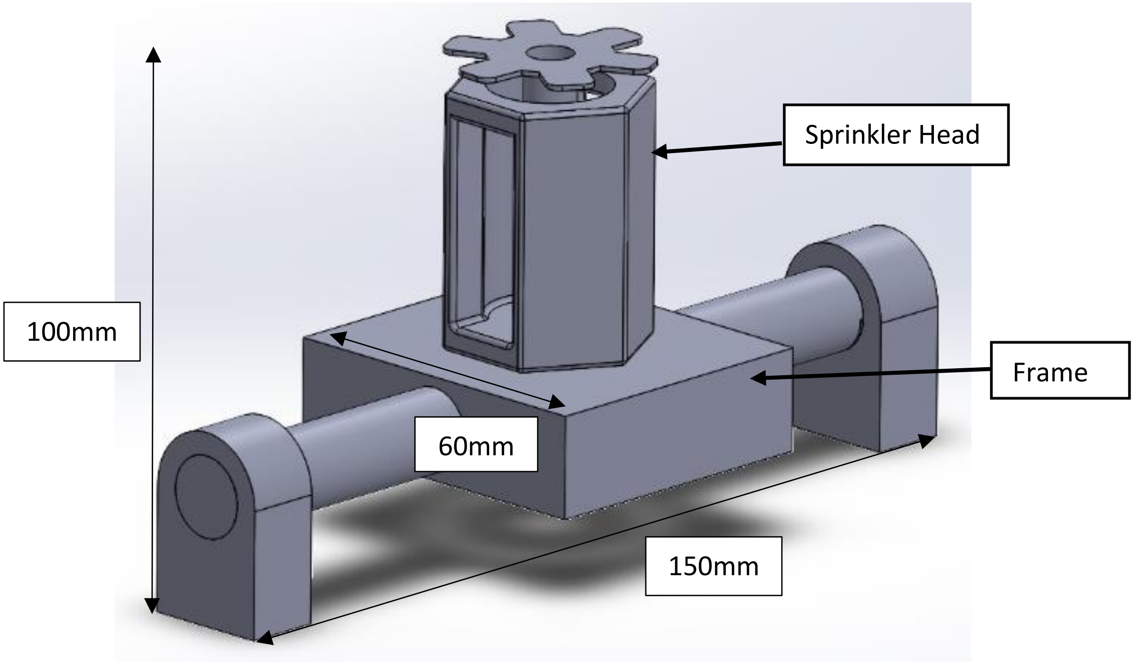

Figure 1:
Sprinkler Head Assembly

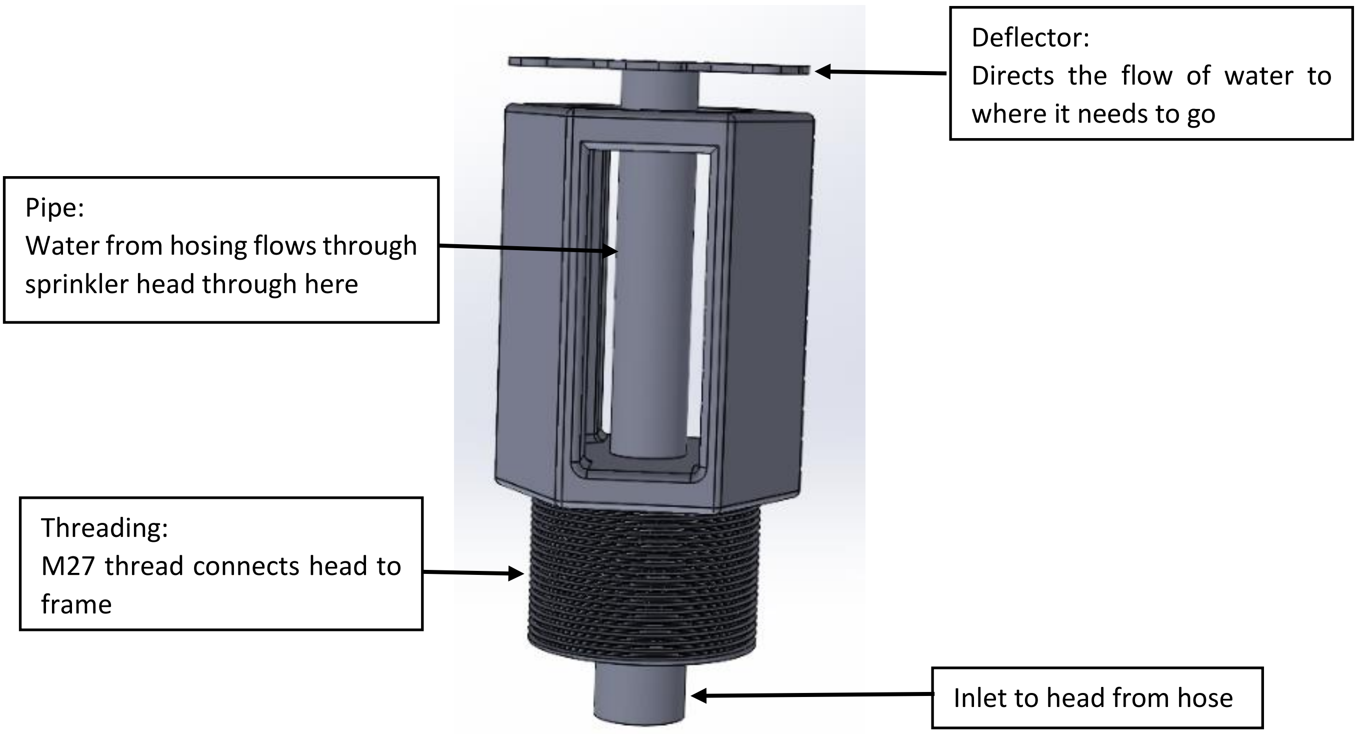

Figure 2:
Sprinkler Head

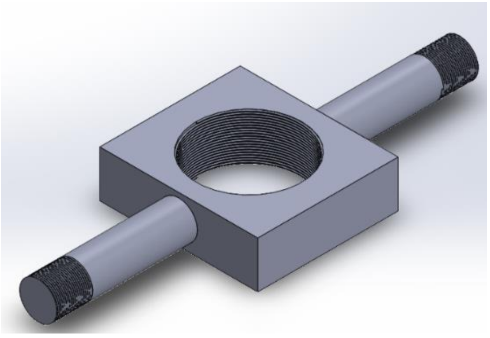

Figure 3:
Frame holding the sprinkler head

Figure 4:
Attaches frame to the roof of building

Key:
Black Dot – Sprinkler head
Blue Circles – Area of ejected water
White Line – Connecting hoses

Hoses to and from pump – the pump is located somewhere convenient on the property (i.e. utility room/garden)

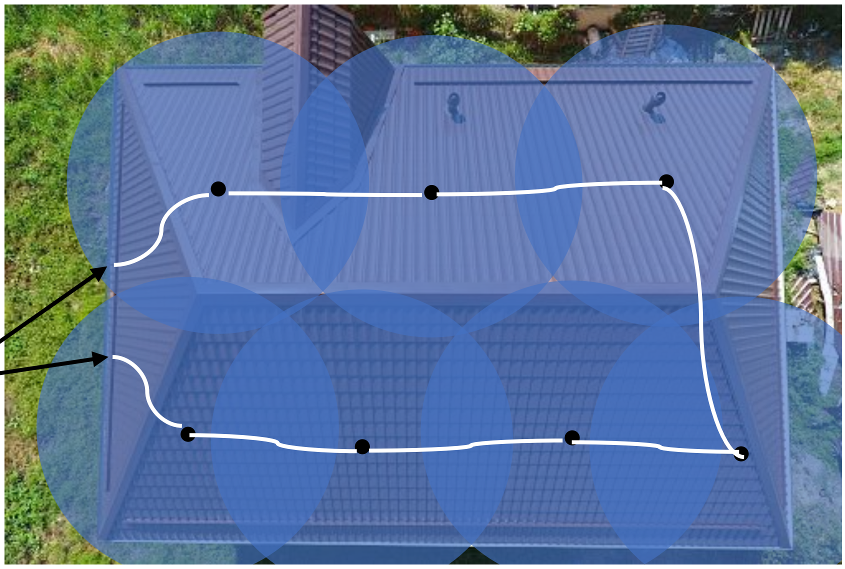

Figure 5:
Rooftop Configuration Example

Section 1(b): Description of Design and its Operation

The design of the wildfire sprinkler system is aimed towards homeowners in areas at high risk of wildfires; this can be in both mountainous and flat terrains. While used in many buildings, with an operational reliability 94% (Council, 2019), they are very rarely considered when looking at extinguishing wildfires. This concept uses ideas from conventional fire and irrigation sprinklers, adapting it to wildfires.

The sprinkler system has three main components, consisting of: the water supply, the hoses and the heads, which are made of Copper. The water supply will be provided by the mains with a pump, of capacity 1000L/min, being installed in a convenient place on the property. Hoses distribute the water to the individual heads which ejects water, in a controlled manner, to extinguish the wildfire around the house. Sprinkler heads will be placed in two separate regions on the property: around the perimeter of the house with the aim of extinguishing fire before reaching the house; secondly, there will be a sprinkler system on the rooftops of the house. This is the last line of defence and will extinguish fires that are too strong for the perimeter sprinklers, as well as dampen any embers that fly onto the house, which could fuel the fire to start spreading on the house. The system operates autonomously and can be installed within 12 hours.

The deflector ejects water to where it is required. This means that the water is ejected more efficiently, reducing water wastage and reducing electricity used by the pump. As well as this, conventional fire sprinkler systems are great for the environment, cutting greenhouse gas emissions by 97.8% (Wieczorek, 2011). Estimates suggest that the installation/initial costs would be in the magnitude of £100 to £1000. With the possible savings of from home insurance, however, the net cost would be much less than this.

Section 2: Design reflection and identification of possible problem areas of the concept for further development

A main limitation of conventional outdoor sprinkler systems is the effect of wind, which probably has the biggest impact on a wildfire's behaviour (Bonser, 2001), as this causes large issues with the placement of water from the system. The solution to this arises from irrigation water sprinkler systems, by using smart controllers to connect to local weather stations that broadcast real-time weather data (Company, 2019). This will mean that output velocities can be adjusted so water can be ejected to where it is needed, to put out the incoming fire.

There would need to be a reliable water supply to the system in the event of a wildfire occurring. This is not always possible for two reasons: firstly, the system may be deployed in a developing country which does not always have a reliable water supply; secondly, the wildfire may cause damage the water supply itself, stopping the system from deploying. A further development of the system would therefore be to make it self contained, without necessary requirements for an external water supply.

Another issue with conventional systems is misting (Anon., 2021), which is usually caused by clogged nozzles or an incorrect water pressure. Clogged nozzles are easily fixed, however, regular testing of the system is required to check if an issue has occurred. Incorrect pressure must be avoided by carefully choosing pump settings. This will be a major design consideration for further development.

Section 3: Selection and evaluation process

Weighting Factor	
1	Low Importance
2	Medium Importance
3	High Importance

Performance Factor	
0	Unsuitable
1	Just suitable
2	Adequate
3	Quite suitable
4	Good
5	Very suitable

Score = Weighting x PF

	Weighting	Design 1		Design 2		Design 3		Design 4		Design 5	
		PF	Score	PF	Score	PF	Score	PF	Score	PF	Score
Selection criteria											
1. Ability of the device to use water as the fire extinguishing medium	3	2	6	4	12	5	15	4	12	3	9
2. Operation capability of the design in rough terrain/mountainous areas	3	4	12	5	15	5	15	5	15	2	6
3. Ability of the design to disperse the water in a controlled manner	2	5	10	4	8	4	8	2	4	3	6
4. Ease of operation and set-up of the device (considering the required number of firefighters and extra training)	2	5	10	2	4	2	4	4	8	4	8
5. Operation timeframe of the device (the design must be able to operate at least 14 hours within a 24h window)	3	5	15	1	3	5	15	1	3	5	15
6. Ease of transportation (either using standard-size road-going vehicles (e.g., flat-bed lorry) or by its own means)	2	4	8	5	10	3	6	5	10	4	8

7. Ease of deployment after transportation (the device must be ready for deployment within a maximum of 12 hours)	2	5	10	5	10	2	4	3	6	3	6
8. Level of environmental friendliness (The device must not cause any long-term contamination of the environment in which it operates)	3	5	15	5	15	4	12	1	3	4	12
9. Level of sustainability	3	4	12	3	9	3	9	3	9	4	12
10. Weight	1	5	5	2	2	3	3	2	2	5	5
11. Dimensions	1	3	3	4	4	3	3	3	3	3	3
12. Degree of compliance with health and safety regulations	3	5	15	1	3	4	12	2	6	4	12
13. Operation capability of the device in non-mountainous (i.e., flat) terrain.	1	4	4	3	3	4	4	3	3	5	5
	Total score		125		101		110		84		107

Reviewing the design brief, it was decided that the most important factors were the ones pertaining to the device effectiveness and ability to be used in rough terrain as these are fundamental [1]; without these the device would fail to meet basic expectations. This led to selection criteria 1, 2 and 5 being given the highest weighting of 3. This, however, must be balanced by its impact on the environment, sustainability, and safety in use. No matter how effectively the device can put out fires, if the result is equal damage to the environment or loss of life, it would be counterproductive; thus criteria 5, 8, 9 and 12 were also given the highest weighting. This balance is best shown by design 4, while it is effective, it would have a noticeable impact on the surrounding environment after each use, thus its lower total score.

Selection criteria 3, 4, 6 and 7 were given a medium weighting of 2. This was on the basis that while each of these are desirable, no design should be fully ruled out based upon them. The ease of transportation, deployment and operation are important factors, but as long as the device is capable of working effectively, and doing so in a safe and sustainable manner, then they can be considered of secondary importance. Designs 2, 3 and 5 each have differing combinations of results in these regards, but each provides a solid concept with their own strengths, hence the relatively small range in their total scores.

The remaining criteria were given the lowest weighting of 1, as each of them are the least relevant to achieving the main aim of the design.

Each of the performance factors were given based on a comparison between each of the designs and a baseline of current devices in use. The ability to operate in rough terrain was fulfilled by all designs except 5 which fell behind due to its lack of mobility and since it was designed for stationary use, this design choice also limits its potential for improvement Operation timeframe was a criterion in which each of the designs deviated the most, ranging from 1-5, design 2 receiving a score of 1 in such an important factor, combined with several other lower scores, helped narrow the choice down to designs 1 and 3. Design 3 had major issues with its complexity and how realistically it could function, especially its cost to benefit ratio, which although was not part of our criterion, helped us decide between the final two.

To conclude, design 1, with the highest score, was chosen as the final design. The idea is both novel and effective, while staying sustainable with minimal impact on the area where it is deployed. Overall, it most closely fits the design brief and has the potential to have a noticeable effect on the overall picture if used and improved properly.

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