NASA's Gateways to Blue Skies Competition
'Advancing Aviation for Natural Disasters

Cerritos College

PROJECT F.I.R.E.

Fire Intervention Retardant Expeller (F.I.R.E)

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Abstract/Summary

F.I.R.E (Fire Intervention Retardant Expeller) is a proposed response to wildfire natural disasters. Detecting and responding to forming wildfires quickly reduces damage and cost and reduces reflex time needed for firefighters. Proposing a collaboration between an expanding public safety system and remodeled and repurposed drones to respond to forming fires quickly to eliminate or reduce their spread is the project objective. AlertCalifornia is a public safety program currently increasing their camera and sensor coverage across California for real-time monitoring. Upon receiving an alert from AlertCalifornia, the upgraded IGNIS drones (DroneAmplified) will deploy, setting a course using Rigitech's software to arrive at the scene. Once at the scene they will use their thermal sensors to identify the location of the fire. The IGNIS drones were originally used for dropping spherical capsules onto land to safely ignite prescribed fires and backburns. The team is proposing an alternative way to use IGNIS, allowing it to carry and drop fire retardant material to the nascent fire. Challenges include determining the appropriate number of stations to be set in cities with the appropriate fleet count of drones to be used for fires. Another challenge would include testing the amount of retardant that will be needed, as well as possible flight time issues. Opportunities include possible partnerships with CalFire departments to station our drones for departure to fire alerts. The modification of other drones, whether repurposed or newly developed, should accommodate heavier payloads and extend flight durations, enabling them to access remote areas effectively.

Objective

Striving for a partnership to improve wildfire response with the goal of safeguarding both the environment and financial stability is the focus of this project. This collaboration is crucial not only for governmental agencies but also the communities vulnerable to the impact of wildfires. Using the numerous camera systems of AlertCalifornia will allow fast fire detection and local drone deployment. Working with swarming technology, AI learning, thermal cameras, and navigation software will allow the drones to optimize their flight path and fire position. Once the drones reach their destination, analysts will determine additional steps to take depending on the severity of the situation. Combining AI and human factors to determine the best approach will lead to the safest, most efficient way to contain the spread of wildfires. Collaborations with AlertCalifornia, Rajant, RigiTech and Drone Amplified could make these objectives possible.

Situation Assessment

Recent severe droughts and rising temperatures have led to increased frequency and intensity of wildfires in California, with eighteen of the state's twenty largest wildfires occurring since 2000. This troubling trend led to the first million-acre fire in 2020, and wildlife is the most impacted.

Low-intensity fires have always been a part of the ecosystem, burning extra vegetation on the forest floors and leaving the soil extra fertilized for trees to thrive in. Animals have an easier time escaping these fires and come back eager to explore the new environment, continuing to thrive in the forests. With the recent high-intensity wildfires, however, most animals fail to escape to safer places, resulting in species of animals becoming endangered. High-intensity wildfires scorch the soil to a degree where tree roots are burned, killing the trees in the process. Soil erosion results in the soil no longer able to support plant life. Invasive species of grass and low scrub can take over the forest, preventing seeds from receiving sunlight and growing. With little to no regrowth, rodents have no seeds to eat, and grazers have no leafy meals, both having no choice but to leave. As a result, carnivores have no prey to eat and are forced to move as well. Wildlife corridors created by the forest canopies, used by roaming species like fishers to avoid detection from predators from above, are burned in high-intensity wildfires as well. With no wildlife corridors left to rely on, these species become isolated in smaller areas where they fail to find a mate or food. During rain, runoff containing ash and debris (harmful contaminants, sediments, and heavy metals) flows into nearby lakes and streams, polluting them, and interrupting the lifecycles of aquatic species like fish and frogs. This also makes the water undrinkable to animals and humans.

Nearby communities can be destroyed by wildfires as well, causing loss of life and property (crops, animals, resources). Wildfires produce smoke, fine particulates, and greenhouse gases that contaminate air, making the air quality in nearby cities poor. This can cause respiratory irritation and serious problems such as bronchitis and asthma. The inhalation of smoke can lead to a lack of oxygen in the body, affecting the circulatory system with issues such as heart attack and heart failure. Wildfires can damage utility poles and fiber lines, which can interfere with communication. Economically, destruction of buildings leads to an annual loss of between $63.5B to $285B, while the long-term health cost that comes from the air pollution (2008-2012) is an estimated $450B.

Two federal U.S. departments take care of the U.S. land: the U.S. Department of Agriculture's Forest Service (USFS), and the U.S. Department of the Interior (DOI). Within DOI, the Office and Wildland Fire (OWF) and four bureaus manage wildfires: the Bureau of Indian Affairs (BIA), the Bureau of Land Management (BLM), the Fish and Wildlife Service (FWS), and the National Park Service (NPS). From there, a network of state departments, industries, commercial partners, and other entities are also involved in wildlife management.

Wildfire management can be divided into three main phases: preparation, response, and recovery. In the preparation phase, actions are made to either prepare for or prevent wildfires and include checking equipment to ensure proper working order, keeping firefighters up to date on their training, and assessing previous year's activities to determine any improvements that can be made. In the response phase, wildfires are detected by methods such as surveillance cameras with AI, followed by an initial attack by firefighters and aerial units, in addition to an extended attack if the wildfire persists. In the recovery phase, efforts are made to re-establish the wildlife affected by the wildfire.

In California, the California Department of Forestry and Fire Protection (CalFire) takes care of wildfires in forests using several aircraft: the S-2T Airtanker, the OV-10 Air Tactical Aircraft, the UH-1H Super Huey Helicopter and the Sikorsky S70i. During the initial attack sub-phase of responding to wildfires, the two helicopters (the UH-1H and the S70i) take a crew to the scene and drop water/foam. The S-2T Airtanker drops fire retardant on the wildfire, while the OV-10 Air Tactical Aircraft serves as the aerial command center that communicates with the crew on the ground.

CalFire, in partnership with UC San Diego's AlertCalifornia system, operates an AI pilot project maintaining 1,039 high-definition cameras throughout the state. The AI filters through the feeds and identifies—with a red box—anomalies that might be due to wildfire, such as smoke. Every time officials confirm the anomaly is indeed a result of wildfire, the AI learns and becomes much smarter in identifying anomalies. Currently, the AI has learned to distinguish between fog, clouds, and smoke. This project has helped officials in identifying fires even before 911 calls were made and has allowed firefighters to arrive quickly to the destination and put out the fire before it grew stronger. The network consists of multiple types of cameras across the state. There are cameras which use 360-degrees capabilities to detect fire and take 12 high-definition frames every two minutes. There are also Forward-Looking Infrared cameras (FLIR), as well as Light Detection and Ranging (LiDAR) remote sensors that can measure distance in a 3-dimensional environment. Biomass and Carbon Estimation are created from the data collected from the LiDAR camera, as well as wildfire modeling from the forest metrics the LiDAR collects. Aside from the cameras AlertCalifornia provides, they also work on Terrain Modeling where the data from the cameras, as well as other advanced scans from forests, are combined to assist in identifying trees and other vegetation in diverse habitats. The project has, in total, invested about $20 million in the past four years from sponsors, including federal investments, grants, and Calfire. Officials are also able to make informed decisions about road closures, utility shutoffs and other critical response measures just by looking at the camera feeds.

In addition, UC San Diego has worked with the U.S. Geological Survey to map nearly all of California using Light Detection and Ranging technology, which provides CalFire with information about vegetation and fuel moisture levels, drought, tree mortality, and other landscape factors that can affect fire behavior. Furthermore, NASA is researching unmanned aircraft and drones that could be useful in fighting wildfires, specifically during the night, when firefighting crews have departed, and the fire is at its calmest.

Team-Defined Use Case:

The proposed concept will be repurposing drones initially used in removing vegetation for the response phase, specifically for initial attack. The drones will be utilizing cameras set by a public program to assist in the drone's response time. Drone Amplified, who created the IGNIS drone, initially used IGNIS for prescribed burn operations by aerially dropping ping pong sized balls to ignite crowded vegetation below.

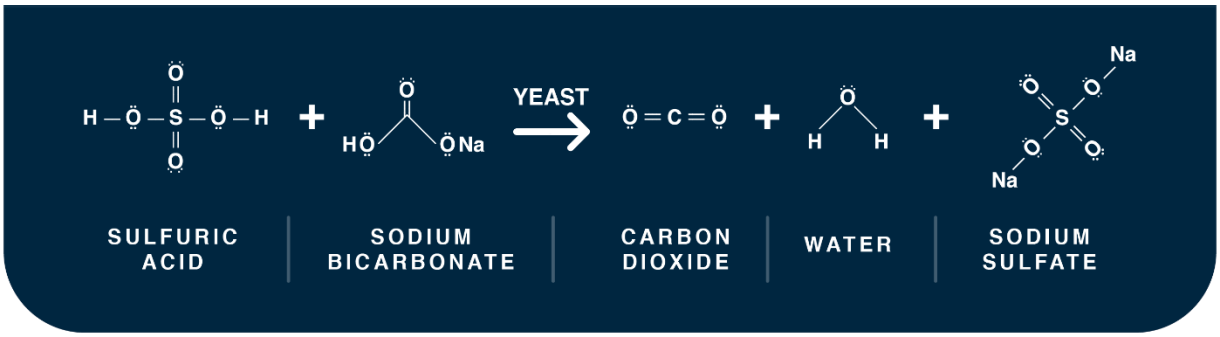
The drones will be using an alert system set throughout California by a public program called AlertCalifornia by UC San Diego. A partnership with UC San Diego will allow the drones to function with the use of the UC's cameras planted throughout the state of California. When the AI detects a wildfire through the cameras it will send a signal out to operators to check for any false alerts. The drones will then be deployed and quickly arrive to the scene of the fire autonomously, which then foam-expanding pellets will be dropped to smother the fire, potentially taking out the fire in its early stages or decreasing reflex time for firefighters. These drones will provide aid to firefighters when poor visibility is present, increase efficiency while swiftly putting out wildfires, and can function with the lack of firefighters to also minimize injury. The drones will be using Rigitech's Rigicloud network to automatically map out the safest route to the location of the wildfire upon receiving an approval from the alert signal. The network will provide the drones with information such as weather conditions and live air traffic surrounding the drone. A tool that is implemented in this software is the multi-drone flight simulator, making it convenient for the user to move a group of drones rather than one by one.

Figure 1 'Ignis' drone by Drone Amplified. "Drone Amplified's IGNIS payload system." FlyingMag,October 7, 2021, https://www.flyingmag.com/drones-wildfire-fighting/.

The drone will undergo modifications based on an existing model from Drone Amplified, a company based in Nebraska. This company created the drone 'IGNIS' to remove large areas of vegetation through ignition, a solution towards removing material that can potentially worsen a wildfire. The mechanism used for the IGNIS are ping pong sized spheres containing a chemical that produces an exothermic reaction. Hardware Modifications to be made to the drone will be using network module by Rajant for a stronger connection between each drone and software. It is Rajant's Breadcrumb Cardinal that

will be used for the drone's strong connection. Cardinal module allows there to be a wireless connection so the drones can precisely manage formation over the fire. In the Rajant specification sheet, it is stated that the Cardinal extends the range from the common Wi-Fi and 5G connections to high-capacity Machine to machine communication. The Cardinal module only weighs 90 grams which will not affect the weight of the drone. The drone will then be using software by Rigitech to automatically set a route for the drone towards the fire location. The location of the fire will be created by the cameras set by AlertCalifornia. The chemical will be modified to an endothermic inducing chemical to be used for smothering fires. The drone will accurately locate the fire upon arriving at the scene, using the precision of Workswell Wiris Pro thermal cameras, which have been expertly modified by Drone Amplified. The model drone IGNIS is currently using the Alta X, modified by Drone Amplified, to have these multiple features. The IGNIS drone can carry a total of 450 spheres with a rate of 120 spheres per minute. It also carries antifreeze along with 450 spheres totaling a load weight of 9.3 pounds. Where the overall weight including the drone and load ends up being around 60 pounds. As for flight time, the drone only ends up being 22 to 30 minutes. The amount is not the greatest, however it is fitting for evaluating the system connection between the drone, AlertCalifornia cameras, and Rigitech's software. In the future, there will be a shift for a more capable drone after fully assessing the system.

The current chemical being used by Drone Amplified for the IGNIS drone is a mixture of potassium permanganate with glycol. The chemical will then be modified to a different chemical found from the findings by Zak Nasser in an article from 2021. This chemical by Zak came from the chemical mixture used in elephant toothpaste, a common science experiment that creates foam, containing Hydrogen Peroxide, Iodine, and Soap. The chemical developed by Zak contains Soap, Vinegar, Baking Soda, and Iodine. From the findings in the article by Zak Nasser, it is stated that the mixture can mix into a foam that can grow from 40 liters liquid to 13 cubic meters of foam. Concerns were raised about the dangers of using the chemicals in the original elephant toothpaste. For example, the formula will end up generating O_2 which is likely to worsen the flames. In comparison, the modified version by Zak will provide CO_2 which will suffocate the fire rather than adding onto the fuel. For this project's chemical it will be modified further from Zak's formula to the formula:



The mixture will be made up of Sodium Bicarbonate, Sulfuric Acid, dish soap and yeast. The goal of this modified chemical is to create an endothermic reaction that yields a high volume of carbon dioxide that will be trapped by a dense foam to effectively contain the flames while firefighters assist the area. Sulfuric acid and bicarbonate are two of the main ingredients found in fire extinguishers which react to produce carbon dioxide, the key product involved in the smoldering flames. Carbon dioxide displaces the oxygen that fuels the flames and significantly decreases the temperature of its surroundings, therefore, restricting the growth of the flames. However, to ensure the efficiency of the fire extinguishing effect, this reaction will imitate the effect of elephant toothpaste, ultimately creating a much denser foam to trap the carbon dioxide over the affected area for an extended period. To create the elephant toothpaste effect, it is

essential for the mixture to contain a catalyst, which in elephant toothpaste is typically yeast and it could possibly also catalyze our desired reaction by working with a strain of yeast that is low pH resistant, for it to withstand the acidic environment produced by the sulfuric acid. As the reaction is being catalyzed, carbon dioxide will form, and the dish soap will serve as a resistant film to prevent the escape of the forming carbon dioxide bubbles and capture them within the foam. Each ingredient will be stored in separate compartments within spheres that will be dropped over the flames. Upon impact the compartments will break thus triggering the mixture of the chemicals causing the mixture of the reactants to form the desired foam within the spheres that will accumulate pressure and break the sphere open and dispersing its contents upon the affected area. The expansion of the liberated foam will significantly decrease the temperature and sequester the surrounding oxygen molecules, thus eliminating the fuel source of the flames and therefore promoting containment while firefighters arrive to the affected area. The chemicals selected for our mixture are chemicals that have been previously used by fire fighters and therefore approved by safety standard regulations. The products of the chemical reaction that are expelled into the environment are carbon dioxide, water (which can be recycled back into the environment) and sodium sulfate which can also be decomposed and assimilated into the environment.

The team's chemical is currently a theoretical compound, which is set for future research testing plans at Cerritos College under the supervision of a professor. This research aims to produce the desired foam the team is focusing on. Current team research is theoretically proven to prevent harm to the environment, the chemical outcomes are dispersed into the environment requiring no cleanup. Another option for chemicals has recently become available. With the help of a subject matter expert, the team has begun investigating efireX, a company that creates "green" chemicals for fire suppression. The company is efireX, a lithium battery fire suppression company creating all natural 100% biodegradable lithium fire suppression. The company has stated in their spec sheet that the chemical is an easy clean up with no Haz-Mat needed, Per- and polyfluoroalkyl substances (PFAS) free, and FDA approved as well as other certifications. This suppression agent by efireX is the most ideal chemical as it has many similar applications, so it will serve as alternative to the team's chemical they have researched if change is necessary for adaptation to current standards.

Necessary Trades:

Team roles required for this concept include cybersecurity programmers, technicians in charge of taking care of the drones, and people overlooking the drones while they are in operation. Cybersecurity programmers will make sure hacking into the drone network is impossible to prevent a disaster. Technicians will be fixing/repairing drones that are damaged during wildfires, cleaning them of any dust or other substances, and conducting routine tests to make sure they are working properly. The overseers will make sure that the drones make it to the wildfire safely.

The initial efforts must prioritize establishing costs of essential roles necessary for the feasibility of this project. There are diverse options that can help with the funding of this project such as Federal mitigation and preparedness grants, this can help fund or replace what was spent on the efforts that were made during a wildfire (Wildfires: Burning through state budgets,2022). Developing divisions and teams will depend on recruiting the following roles:

- Aviation Operations Manager- This role will make sure that all drone operatives are running effectively. Teams in the following categories will be needed.
    - Communications- This role will make sure that the drones do not have any complications while on route. Managing any aircraft dangers and tracking their progress. Ensuring aviation regulations and safety standards are met to maintain a safe operating environment.
    - Technicians- This team will keep all our drones running up to par to any standards necessary. Responsibilities such as maintenance checks for proper functionality and performance. Troubleshooting issues like signal loss, communication errors or any equipment malfunctions.
- Safety Coordinators- This role will be evaluating and analyzing the possible dangers that our project may face while utilizing drones. This team will analyze prior and post incident hazards.
    - Drone safety team- They will be making sure that our drones are following safety protocols to accomplish their goals.
    - Environmental department- They will oversee wildfire prevention efforts such as brush removal, local hazard mitigation plans, and community wildfire protection plans.
    - Chemical Research Team- This team will be tasked with improving the components used to extinguish fire. Improving the aftermath of chemical use to reduce harm to the environment and wildlife.
- Information Systems Division- This division will be analyzing and reporting on data collected from weather conditions, payload capacity, and security measures being taken.
    - Cybersecurity Programmers- Programmers will be maintaining data breaches from happening during natural disasters. With wildfires facilities can be damaged and impede our team from defending against a cyber-attack but having a plan for when events like this happen will be up to this team.
    - Business Analysts- Our analysts will study and investigate the impacts that wildfires have in various aspects to improve our response processes. Investigating drone technologies and finding resources to improve our response efforts.
    - Hardware and software- Having our drones well equipped and responding as they should is a particularly important focus point that this team will have. Making sure the operating system and flight controller are functioning properly. Navigation systems and sensors are running as they should.
- Finance Department- Our finance department will be comprised of accountants, budgeting, and fund outreach divisions. This will make sure the organization is tracking expenses, allocating funds, and increasing funding networks.
    - Accounting- Our accountants will diligently maintain comprehensive records of all expenditures, essential for informed decision-making in the future.
    - Budgeting- The budgeting team will assist in allocating funds strategically to enhance our initiatives. Implementing financial plans that align to project goals.

Fund Outreach- This team will be dedicated to identifying potential funding sources for our wildfire prevention initiatives, including government outreach and public partnerships.

Concepts of Operations Overview

Integration Depiction

Team Falcons have created a Gantt chart, located in the appendix, displaying every milestone leading to the final phase of nationwide deployment in 2035. Team Falcons is preparing to develop a conceptual prototype by the end of phase 1, ending in 2025. The team's near-term goals revolve around acquiring hardware and testing product cohesion. Currently, the team has arranged a meeting, with the help of an SME, with both Rajant Corporation and DroneAmplified for June of 2024 to discuss hardware that will be needed. During the meeting, the team also plans to discuss expected delivery time and cost for the drone by DroneAmplified and the Cardinal Network Module by Rajant Corporation. Team Falcons plans to gain access and arrange meetings with AlertCalifornia and RigiTech by June 2024. For phase 1, the team plans to have a conceptual prototype that can locate a fire and accurately deploy retardant. To achieve this goal, the team will combine existing technologies, drones by DroneAmplified, camera AI alert systems by AlertCalifornia, and a strong network module by Rajant Corporation. The team will be using the manufacturing equipment available in the engineering department at Cerritos College to complete hardware modifications by December 2025. With the help of a professor from Cerritos College serving as a supervisor and SME, the team will work to create a foam retardant that follows current standards and regulations. The goal for phase 1 is to reach Technology Readiness Level 5 (TRL-5). For the second phase, ending in 2026, the team plans to integrate all components of the drone with the route mapping system, known as RigiCloud. Successful integration will allow F.I.R.E to autonomously create the best path considering weather conditions. During the second phase, the team aims to reach TRL-7, demonstrating F.I.R.E.'s ability to receive information and respond to the accurate location. The initial testing will be done by 2026, which involves the drone putting out a controlled fire to test the system cohesion. After this test, the team will gather results to then implement future improvements such as longer flight time, higher payload capacity, and efficient chemical variations. For the third phase, the team has a goal set to deploy the first station in Southern California by 2027. Once the first station is working with successful deployments, the team will launch multiple stations throughout the areas of California affected by wildfires by the end of 2028. During this phase, the team also plans to partner with AlertCalifornia to extend coverage of camera systems to other states. The goal for the fourth phase, ending in 2035, is to cover every state affected by wildfires.

Future Improvements: The drone's main issue is the flight time it has, limiting the distance it can cover for response. This issue will only be temporary as the project will investigate larger drones that are capable of long-distance flight and transporting heavy payload. Choosing the larger drone would be ideal; however, the cost would be significantly higher. It is best to experiment with the smaller one, already equipped with the sphere dropping mechanism, to assure success in connection between the drone, the software planned to be utilized and the AlertCalifornia system. There are other companies that were researched in the selection process such as WISPR Systems, and Vulcan UAV. WISPR Systems' Ranger Pro drone can carry 7 pounds of payload with high torque motors that manage winds up to 50 miles per hour, and 360-degree LiDAR collision avoidance. Vulcan UAV's Raven Drone is capable of carrying max load of 25 kg or 10 kg while maintaining high speed. Both these companies provide ideal drones but would add an extra cost since the project would still need the sphere-dropping mechanism from Drone

Amplified to attach to the stronger drone. Another crucial improvement to be made is a more efficient battery for the drone to be able to have more flight time and more power to travel longer distances. The current flight time is only 22-30 minutes, which is ideal for the first testing, but will be later switched out for a heavier battery that will go along with the stronger drone. One improvement that will be gained over testing and implementing is the efficiency of the team's chemical that will be used in the pellets to gain the perfect mixture for the foam retardant.

Future Partnerships: There are partnerships the team plans to work with for future continuation of Project F.I.R.E. The team has contacted Drone Amplified for assistance in understanding the drone better and discussing costs of services and drones. Initially, there was a meeting set for the week of May 6th, but issues interfered which led to the rescheduling of a future meeting. No date exactly set as of right now, but there is contact with a representative of Drone Amplified. Contact was attempted with both RigiTech and AlertCalifornia; however, no response has been provided as of now. The team plans to further attempt contact to reach to an agreement on costs and for further information to evaluate project F.I.R.E. AlertCalifornia's partnership would be the most critical as it is the main connection with the AI detection camera systems to locate the fires in its early stages.

Factors of Integration:

For integration, the major factors that will interfere with our goal of launching our repurposed drones in the near future are lack of regulations for aerial assistance of smaller drones that will be used for firefighting. There has been a regulation set for liquid quantity a drone is allowed to carry, but our chemicals will be used as a fire retardant and will expand by an estimated 331 times the amount. This only makes it more efficient and can remain under the regulated amount while still being able to suppress the fire.

A concern raised by the team was how some of the cameras lacked the feature of 360 degrees rotation or even 180-degree rotation. While researching, the team found a company called Lindsey Firesense who provided 360-degree surveillance cameras with automatic electricity shutoff. The pricing for one of these full-proof cameras that will be ideal will cost 13,000 dollars for a single unit, including the antenna and communication per camera. After a team discussion, it was a clear idea to focus on cameras currently in place that can be used. After further investigation, the team found the UC San Diego program called AlertCalifornia, who partnered with entities like CalFire and Southern California Edison. This makes our project more cost-effective and reduces the initial investment required to begin integration with drones and surveillance system. AlertCalifornia, with their partnerships, have also expanded past California and started placing surveillance in Nevada and Oregon. From this expansion, they created ALERT Wildfire, which is based at University of Oregon and University of Nevada. With more partnering universities and companies, the coverage of surveillance will expand, addressing the challenge of nationwide surveillance not being readily accessible, as this was only limited to California. This is currently still a slow process, and the issue is still the needed funding to branch out to other states. However, this opens the potential to bring partnerships together across the country to deploy across the nation in this battle against wildfires, which is one of many set goals for the future.

A major concern that has had multiple solutions in the past was finding a way to transport drones over long distances. The option that appeared to be the most favorable one was using a strong network module for connection shifting. The module is called Rajant Cardinal. This module will help remain in connection with the drone for tracking its location in case of any issues the drone may face. The module serves as a connection link between multiple drones to coordinate a precise formation to cover the area of

the fire. The software that will be utilized for routing towards fire will be the RigiCloud software by RigiTech to automatically create routes for drones. RigiCloud uses its own module similar to the Cardinal; however, it only uses 4G connectivity while Rajant's Cardinal is not limited to only Wi-Fi or LTE. The drone will only be using the software used for RigiCloud as it will route the drone based off possible dangers posed by weather conditions, air traffic, and other potential hazards.

As for public acceptance for the project's autonomously responding drones, concerns by the public may question whether the drones or system should be trusted since it is working on its own. For that reason, the project will have operators responsible for checking the signals sent out by the AI detection to make sure it is not a false alarm of any sort. The drones will also be accompanied by firefighters who are also responding to the same signal. However, the drones will be arriving before the firefighters to eliminate the early-stage fire or suppress the fire long enough for firefighters to arrive. This will give firefighters more time to arrive at the scene. Suppressing the fire would also lessen the dangers minimal for firefighters that will arrive at the fire.

Support System Requirements:

The Rigicloud software that will be used for the automatic route generation is all cloud based. That means that it can be accessed from anywhere such as through the mobile app or website. The support system requirements are very minimal for access to the routes, potential hazards alerts, and population density map. As for access to surveillance systems provided by AlertCalifornia, those are also accessible through their website for public viewing while the open-source data they collect and use for these AI detections are shared with business partners and institutions. For the drone it will only follow routes to arrive at the fire location then switch to the thermal camera to accurately locate the fire which will require a bit more power to run those sensors. Overall, the system requirements are very minimal on combining these services with the drone.

Cost/Return on Investment:

Considering the damages wildfires have brought to the United States costing to an amount of around $6-8 billion annually. Then according to the VerticalMag article from 2017 by Elan Head, expenses on aircraft to be used by CalFire costs around $20 million each for their new fleet replacement which they have chosen to go with the new Sikorsky S-70i Black Hawks. This did not even include the cost of training and mission equipment. This data was 7 years ago so the price for helicopters is inevitably higher today. The price for a single drone that was found from an article on Drone Amplified drones was $45,000 for each unit. However, this price may be different as it is not up to date. For the Rajant module Cardinal, contact has been made with someone at Rajant Corporation who will meet with the team in the future to discuss costs and services. The team has also contacted Drone Amplified for a meeting to discuss estimated bulk price and the sphere dropping mechanism on its own. There will also be pricing that will come with the cost of implementing stations within fire departments, and connecting to the services by RigiTech and AlertCalifornia but it will certainly be under the price of a single helicopter used by CalFire. There has not been any response from either AlertCalifornia or RigiTech so it is a goal for the team to attempt contact once again.

Conclusion

In conclusion, the team has contacted Dan Justa the Vice President of Business Development at DroneAmplified and Don Gilbreath the Vice President of Systems at Rajant Corporation. Future meetings have been agreed upon to improve the viability of the project. The team strives to have contact with representatives at AlertCalifornia and RigiTech soon. The team has been receiving support by a Subject Matter Expert (SME) in Emerging Technology named Bruce Arvizu who used to be a Battalion Chief at LA County Fire Department, so Bruce was very helpful meeting with the team giving feedback on writing and providing information that would help. Bruce is currently working with a lot of emerging technologies as an Information Technology Analyst, Bruce has helped the team gain contact with companies like Rajant and plan to contact more that may have a focus related to the team's goals.

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