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Innovative Fire Fighting Strategy

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Abstract

Recent developments in heavy weapon design can be applied to fighting forest fires since both situations involve hazardous environments that present a high risk of damage to physical assets and extreme danger to human participants.

In military applications, heavy armored or robotic systems are designed to match the task at hand. For example, tanks are used to break out a fortified area, robots are used to clear mines and obstacles, and aerial or artillery bombing precedes every ground attack. Similarly, the proposed Fire Fighting Tank & Robots (FFTR) and Fire Fighting Bombs (FFB) would be designed to meet the rough duty of forest fire suppression. The FFTR crew (4) will carry out their firefighting activity without leaving the vehicle, exactly like the crew of a main battle tank during a military operation.

The advantages of using a FFTR include: the ability of operating within the fire itself (FF robots), the ability to clear its own path or to create firebreaks, and continuous operation in cooperation with chemical airdrops or other firefighting techniques, without the need to withdraw or protect human firefighters.

Furthermore, the proposed FFTR concept includes a unique liquid fire-suppressant delivery system, a “gun” that applies liquid and gas mixing technology developed for use in rocket technology thus having a firefighting capability of almost 10 times that of conventional fireman's hose. The same technology of liquid and gas mixing is used with the FFB to intensify the aerial firefight eight folds as compared to present methods. This means that a medium category, low cost, firefighting aircraft (Air-Crane helicopter) will be practically converted into a super heavy category aircraft (747-400 Supertanker), which is very expensive and difficult to operate.

To shorten the R&D stage, existing components and technologies will be used.

1. Introduction

Recent developments in heavy weapon design can be applied to fighting forest fires since both situations involve hazardous environments that present a high risk of damage to physical assets and extreme danger to human participants. In military applications, heavy armored or robotic systems are designed to match the task at hand (Sapaty, 2015). For example, robots are used to clear mines and obstacles, and aerial or artillery bombing precedes every ground attack. Similarly, the proposed Fire Fighting "Tank" & Robots (FFTR) and Fire Fighting Bombs (FFB) would be designed to meet the rough duty of forest fire suppression. Furthermore, the proposed FFTR concept includes an Advanced Firefighting technology (AFT) gun (AFT, 2022) that applies liquid and gas mixing technology developed for use in rocket technology thus having a firefighting capability of almost 10 times that of conventional monitors.

The FFTR will be operated by a crew of 4 firefighters: the commanding officer, the driver and two FF robots operators. The advantages of using a FFTR include: the ability of operating within the fire itself (FF robots), the ability to clear its own path or to create firebreaks, and continuous operation in cooperation with chemical airdrops or other firefighting techniques, without the need to withdraw or protect human firefighters.

To retard wildland fires, fire-retarding material is typically dropped into, or in front of the advancing fire from aircraft such as helicopters or airplanes. To be effective, the conventional Aerial Firefighting dropping must be performed from an altitude no higher than 60 m above the treetops (Lovellette, 2000). But such low flights are extremely difficult and dangerous, particularly at night. The FFB will be dropped from any appropriate altitude and be activated at the most effective distance above the fire.

The basic Fire Fighting Bomb structure will be similar to the conventional aerial bomb. The explosive fill will be replaced by a solid propellant (Sodium-azide) and a bulk of water. The heavy high fragmentation steel body will be replaced by biodegradable material or aluminum shell. Once the requisite threshold has been reached or exceeded, the FFB fuse ignites the solid propellant resulting in a gas bursts into the water tank that forces the bomb shell to open. The opened FFB will release a huge fire-retarding aerosol cone precisely at an optimal level above the fire, resulting in effective rapid extinguishing as compared to conventional methods. This means that a medium category, low cost, firefighting aircraft will be virtually converted into a super heavy category aircraft, which is very expensive and difficult to operate.

To shorten the R&D stage, existing components and technologies will be used.

2. Fire Fighting Tank & Robots (FFTR)

2.1. The FFTR system

The FFTR system (see Fig. 1) will include the following components:

- Firefighting vehicle
- AFT main gun
- Two firefighting robots
- Camera drone

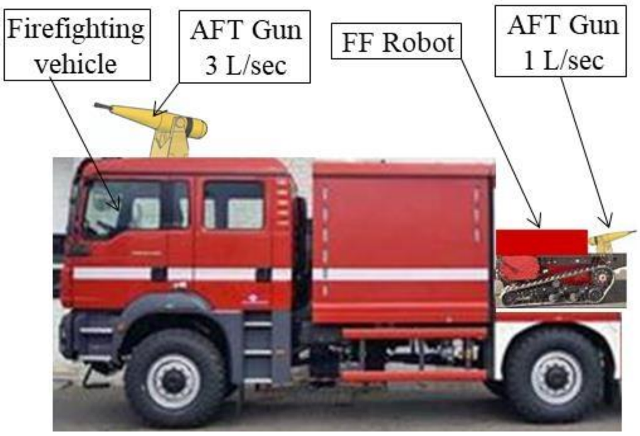

Fig. 1 Fire Fighting Tank & Robots (FFTR)

The FFTR will be operated by a crew of 4 firefighters: the commanding officer, the driver and two FF robots operators. The commanding officer will operate the main AFT gun and the camera drone.

2.2. Firefighting vehicle

The FFTR can be based on MAN TGM 4x4 fire truck, a Volvo FMX, a Mercedes Benz Actros and many other vehicles.

The chassis and the outer shape of the cabin will remain the original one, but all the other parts will be modified to fit the FFTR tasks.

The cabin interior will be fitted for the 4 crew members (instead of the original 6) and the rest of the space will be used for computers and control panels.

The cabin will be sealed against the chemical and biological contaminations and will have a Temperature and Humidity Control (THC) that maintains environmental conditions so that the firefighters can comfortably work in.

The estimated total FFTR weight will be 15000 kg (33070 lb.). Special design efforts will be made to develop a Rapid Deployment (RD) FFTR, weighting only 10,000 kg (22,050 lb.) that will be air transportable by helicopter.

2.3. The main AFT gun

The major innovation of the FFTR firefighting system is based on the Advanced Firefighting technology (AFT) gun (see Fig. 2), which is based on rocket technology and its application to liquid and gas mixtures (AFT, 2022).

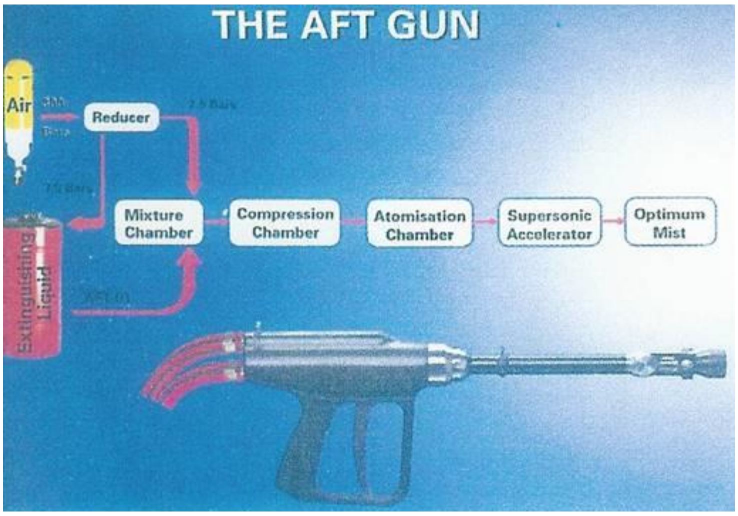

Fig. 2 The advanced firefighting gun

The AFT Gun technology creates a narrow distribution of an ultra-fine water mist (100-150 µm) that covers much larger surface area as compared to the conventional water monitor (almost 50 times). This results in rapid cooling of the burning area, due to extensive heat absorption by water evaporation. The combined effect of cooling and blanketing, results in effective rapid extinguishing of the fire. The AFT gun uses significantly less water (almost 10 times) as compared to conventional systems, hence reducing the total FFTR weight and extending time between resupplies.

The AFT gun generates a lot of steam that endangers the fire-fighters in their direct fire extinguishing actions. Operating from the protected FFTR and using the FF robots, solves this problem in a very effective way.

The roof mounted main AFT gun will be developed similar to the existing one, but with larger flow rate and lancing distance.

The main AFT gun will be mounted on a special, remotely controlled weapon station, similar to the medium caliber weapons installed on any type of military vehicles.

2.4. Firefighting robot

To shorten the R&D stage, an existing robotic platform can be used such as the TC800 FF Colossus, among others (see Fig. 3).

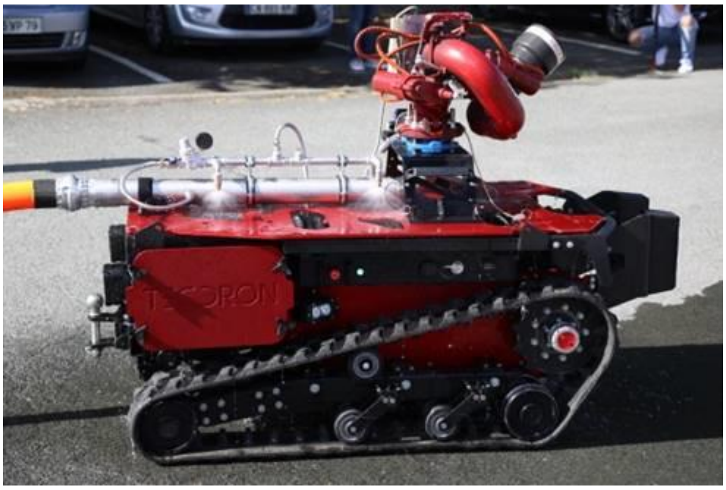

Fig. 3 Firefighting robot TC800 FF Colossus

TC800 FF is a remotely operated robot with autonomous navigation capabilities designed to assist fire-fighters during operations.

The FF robot's upper deck will be used for the installation of the existing AFT gun, a water tank and pump.

Most of the firefighting robots in development or being used today are tethered by a fire hose which supplies water, allowing continuous operation with a running time of 2-4 hours (see Fig. 4).

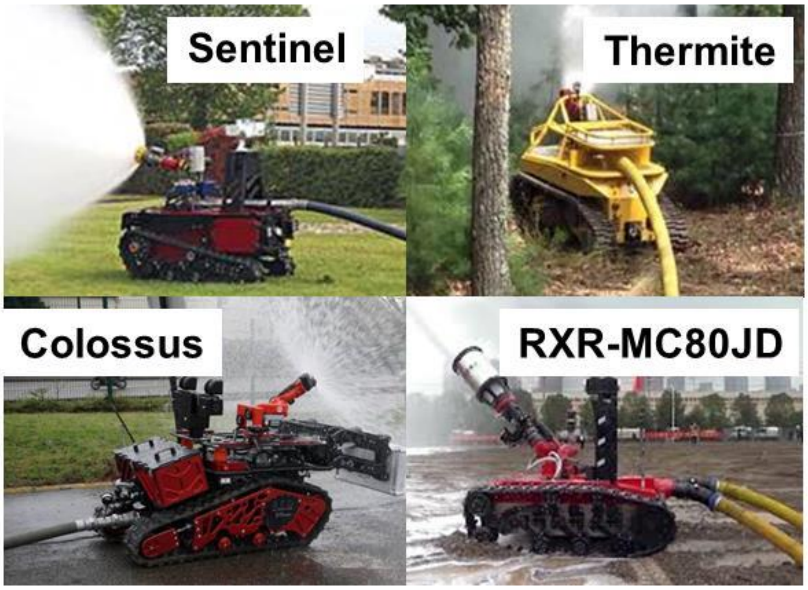

Fig. 4 Firefighting robots tethered by a fire hose

This heavy and relatively rigid hose disrupts the robot's maneuvering to overcome obstacles, especially in forested area.

One of the few water-autonomous firefighting robots is the MVF-5 U3 Multifunctional Remote Controlled Robotic System. It is equipped with 2500 l water tank but weights as much as 16000 kg and is very robust and slow.

The proposed firefighting robot will be equipped with AFT gun which uses significantly less water (almost 10 times) as compared to conventional systems. For example, the proposed robot equipped with 250 l will have the same firefighting capability as the MVF-5 U3 Robotic System but weighting only 1300 kg.

This unique quality enables the robot to be air-transportable taking its place immediately with the first attack, which is the most important to prevent fire expansion.

The FF robot will be equipped with special tools to cut trees and bushes for fire lane formation and FFTR's pass-way clearance similar to these installed on Russian Uran-6 (see Fig. 5).

Fig. 5 Uran-6 unmanned multifunctional demining system (Army 2021)

At the front of the Uran-6, there is one bulldozer blade and standard Flail tool, the heavy metal parts (chains and balls) of which will be replaced by a flexible part of the fire bat.

3. The Fire Fighting Bomb (FFB)

3.1. Hybrid Fire Extinguishing Systems (HFES)

Hybrid media is a combination of inert gas, typically nitrogen, and atomized water that creates an atmosphere that does not support combustion (Raia 2014). The inert gas is used to atomize the water into small, 250 µm (10 µinch) droplets. The atomized water droplets provide a large available surface area for heat absorption, and are easily converted to steam to provide cooling and oxygen dilution.

Fig. 6 Hybrid fire extinguishing nozzle discharging

The hybrid media discharge is regulated by nozzles operating at a controlled nitrogen pressure that controls the discharge rate. Water is delivered to each nozzle at a controlled flow rate, mixed with the nitrogen, and atomized into small droplets (see Fig. 6). The longer suspension time, and the nitrogen, makes Hybrid Fire Extinguishing Systems effective on concealed or shielded fires. In many instances, these fires would not be reached by larger droplets that tend to fall directly to the ground. The cooling effect of water mist takes place when the water mist droplets absorb the heat radiation from the fire. Nozzles discharge fine water mist at high velocity wetting the fuel and the area around the fire. The pressure employed in the water mist fire protection system is a key aspect in the fire extinguishing quality of water mist. Oxygen displacement happens at the heart of the fire when the water mist droplets turn into vapor and take oxygen from the fire.

The nitrogen is stored in high pressure canisters but can be also generated by Sodium-azide reaction. Sodium-azide is the gas-forming (nitrogen) component in many car airbag systems. Once the requisite threshold has been reached or exceeded, the airbag control unit will trigger the ignition of a gas generator propellant to rapidly inflate a fabric bag.

These beneficial water mist attributions were used for Fire-Fighting Bomb (FFB) development.

3.2. Fire Fighting Bombs (FFB)

The combination of climate changes and the expanding human development in the wildland-urban interface create devastating fires that are burning and spreading more quickly than they did 20 years ago. To retard those fires, fire-retarding material is typically dropped into, or in front of the advancing fire from aircraft such as helicopters or airplanes.

The basic Air Fire Fighting Bomb (AFFB) structure is depicted on figure 7.

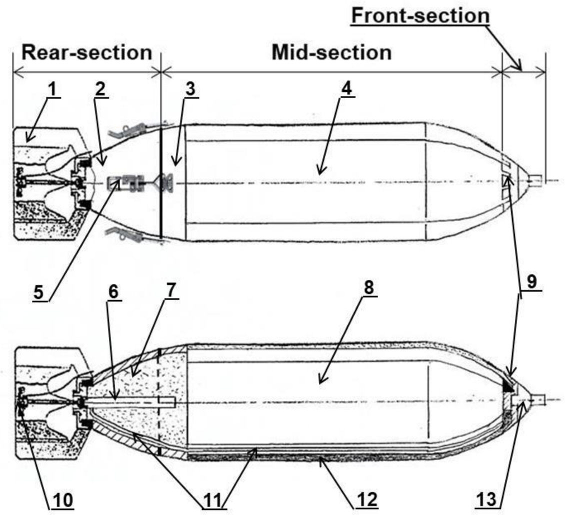

Fig. 7 The Fire Fighting Bomb basic structure

The explosive fill will be replaced by the Sodium-azide propellant and a bulk of water. The heavy high fragmentation steel body will be replaced by biodegradable or aluminum parts.

Once the required gas pressure is exceeded, the FFB case disintegrates, creating an ultra-fine water mist similar to the HFES nozzle (see Fig. 6). Exactly as the AFT technology this water mist will cover an enlarged surface area as compared to the conventional aerial firefighting resulting in effective rapid extinguishing using significantly less water as compared to conventional methods.

To be effective, the conventional Aerial Firefighting dropping must be performed from an altitude no higher than 60 m (200 ft.) above the treetops. But such low flights are extremely difficult and dangerous, particularly at night. Most of the aviation-related wild-land firefighting fatalities results from failure to maintain clearance from terrain, water, or objects. The FFB can be dropped from any appropriate altitude and be activated at the most effective distance above the fire (see Fig. 8). This will eliminate completely the aerosol losses and will increase the fire extinguishing efficiency. In case of unexploded FF bomb, there will be no human casualties due to the fact that FF robots will operate on the ground.

Fig. 8 FFBs opens on an optimal level above the fire

To demonstrate the FFB fire extinguishing efficiency we compare it to Erickson S-64 Air-Crane fire-fighting helicopter. The Air-crane can be fitted with a 2,650-gallon (~10,000 liter) retardant material tank to assist in the control of bush and forest fires.

Let's take as an example a 200 L (66 gallon) FF bomb. The estimated weight of the external body and the propellant will be approximately 50 kg (110 lb.), so the total weight will be 250 kg (551 lb.). The Erickson S-64 Air-Crane helicopter can carry 40 of such bombs at 10,000 kg (22,050 lb.) total weight.

The FFB efficiency will be similar to that of the AFT gun (10 times higher) but to be on a safe side, let us assume a lower value of 8. The outcome of this assumption is that the fire-fighting capability of 200 L FF bomb will be equal to 1600 L of the conventional water dropping. If we multiply this water volume by the FFB number (40) we get 64000 L, which is similar to water carrying capacity of 747-400 Supertanker.

This means that a medium category, low cost, firefighting aircraft has been virtually converted into a super heavy category aircraft, which is very expensive and difficult to operate.

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