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Real-time Monitoring of Forest Using High-Altitude Pseudo-Satellite

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Abstract - Other than the defence, a forest is an area where continuous and real-time surveillance is required to protect the forest from Poachers, Forest-fire, ill-legal felling of trees, ill-legal mining, and monitoring of on-duty forest guards. Due to terrain or geographical constraints and poor availability of manpower, an aerial platform makes the task easy by providing a bird's eye view, but the existing platforms are unable to provide real-time data continuously for long period. This article will show why we need real-time monitoring of forest and how High Altitude Pseudo-Satellite (HAPS) can full-fill the existing capability gaps in "real-time monitoring" and helps to secure forests. Using HAPS we can detect ill-legal activities/forest-fire and communicate the information in real-time.

Key Words: Pseudo-satellite, HAPS, real-time monitoring, forest, forest-fire, UAV.

1. INTRODUCTION

Forest is a large area with rich flora and fauna. Gathering data about the forest using remote-sensing techniques for mapping forest & biodiversity, precision forestry, and sustainable forest planning management [1], and recording the information which is not visible to humankind is relatively easy. Due to its vastness, difficult terrain, and wildlife, patrolling all day for the protection of forests and wildlife in all weather conditions is very difficult for human beings. So we need an aerial platform having long endurance and can provide high-resolution coverage 24*7 in all weather conditions. So that, if some ill-legal or some human activity or forest fire is detected it should be communicated in real-time because beyond that forest geography is such that if we send a team one day after then that is too late.

1.1 Existing platforms

"Remote sensing is the art and science of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device without being in physical contact"[2]. We can mount the required sensors on two types of platforms for remote sensing.

1.11 Air-born platforms – "Drones and aircraft" fall into this category. They can provide very high-resolution data because of their low flying ability but due to limited power supply, they are unable to provide continuous information for a longer period.

1.12 Space-born platforms- "Satellites" are grouped in two categories based on their orbits. (a) Earth synchronous-satellites orbit at an altitude of 36000km above the equator and move from west to east which makes them stationary relative to the Earth. This helps us to get continuous information on large areas. It is used for weather forecasting and telecommunication. These satellites orbit at very high altitudes, so we get relatively low-resolution data. (b) Sun-synchronous/Natural Resource Satellites- Satellites present in Low Earth Orbit (LEO 800-1000km altitude), move from the north pole to the south pole and provide high-resolution data but at frequent intervals[]. Hence continuous monitoring does not facilitate.

Both the existing platforms have their own capabilities and limitations and based on their capabilities they both have different tasks to perform.

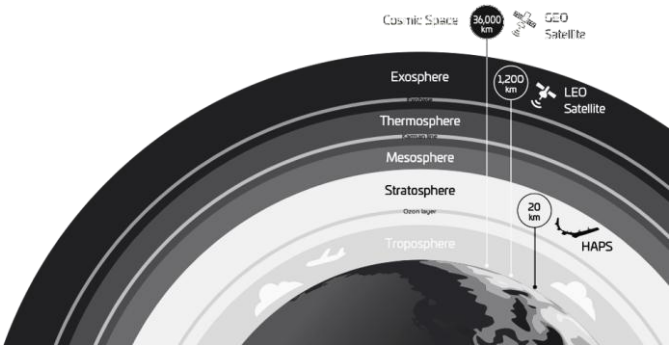

Fig-1: altitude of different platforms

2. High-Altitude Pseudo-Satellite (HAPS)

High-Altitude Pseudo satellite is a solar-powered high altitude long endurance UAV, watching over Earth from the stratosphere. The term "Pseudo-Satellite" is used because of its capability to stay above an area for a very long period like a satellite. Its flying altitude is just above the commercial aircraft and drones but operates like a Satellite. The best working altitude is 20km, 8-10km above commercial airlines. Here the wind speed is sufficient enough for them to hold the position for long period. It can remain in its position for weeks or months. Technologically the main advantage of

this altitude is very less meteorological events with light winds. At an altitude of 20 km despite the curvature of the earth, it can cover an area of radius 200km. The potential to stay above an area of a radius of 200km for months, makes it the best-suited platform for real-time monitoring/surveillance of Forest and complementing the existing Air-born and Space born platforms.

2.1 Operating principle

"During the day, photovoltaic cells placed on the surface of the aircraft recover the energy needed for flight and instruments. The energy necessitated for night flights must be added (stored in batteries). At night, the stored energy is also returned for use by propulsion and onboard instruments. When applied in a UAV system to avoid flight time limitations, such a concept improves the endurance limit no longer in terms of on-board energy autonomy but to the time allocated between two maintenance visits, which can thus be up to several months" [3].

Fig -2: High altitude pseudo-satellite

3. Real-time monitoring

Real-time monitoring[4] provides a continuous flow of relevant and current data with low latency, from which administration can immediately identify serious problems. Alerts can be more quickly routed to appropriate staff through an automated system – for mitigation [4].

The following will briefly present the area and where HAPS can be used for real-time monitoring

3.1 Detecting ill-legal activities

In forest-related issues, our number one challenge is the "ill-legal trade of wildlife". After Drugs and ill-legal Arms, the ill-legal wildlife trade is 3rd highest ill-legal commodity (5-20 billion $). Ill-legal logging and felling of trees is another big challenge, due to shortage of man-power we cannot go to all area and do patrolling. So by using the HAPS, we can scan the entire forest, what activities are happening, and where those are happening in the forest, if detects any ill-legal activities then HAPS can vector the patrolling team and drones to that point for taking the necessary actions. Forest lands are given for mining, sometimes what happens certain industries mine more than the allotted area. So the ill-legal mining should also be properly monitored in real-time.

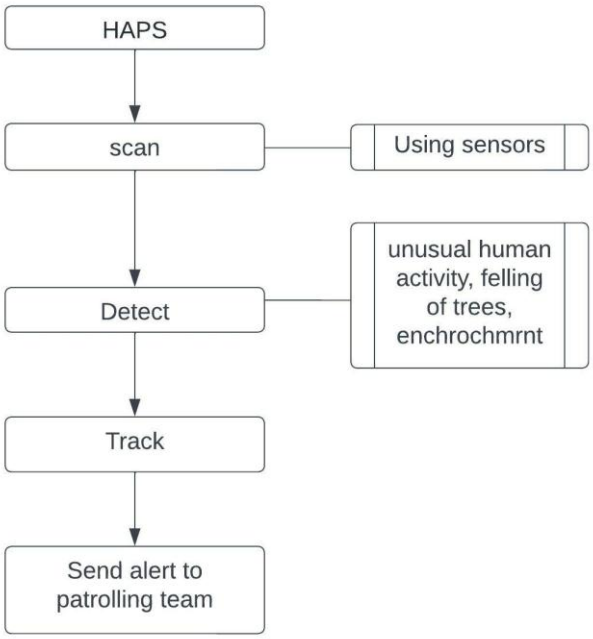

Fig-3: real-time surveillance by HAPS

3.2 Forest fire / Wildfire

One of the major disasters in forest areas is a forest fire. These fires are the major cause of forest degradation and have adverse ecological, social and economic effects. It includes loss of timber resources, loss of biodiversity, depletion of wildlife, loss of carbon sink resources, global warming, reduce forest cover, increase soil erosion and change in the microclimate of that area[5].

The causes of forest fire are classified as "environmental" and human-related" causes[5]. Environmental causes are largely due to temperature rise, dry vegetation, high wind velocity causes friction of bamboo resulting in sparks setting off fires, volcanoes, etc. Human activities such as fire lit to ward off wild animals, fire initiated to promote the growth of grasses in the next growing seasons, and practising shifting cultivation in an uncontrolled manner leads to a forest fire.

Fire behaviour is influenced by parameters like the nature of the fuel, temperature, wood, terrain conditions, surface winds, availability of fuel, topography conditions, and slope conditions[5]. Fire moves fastly in the direction of the wind and moves in the direction where the availability of fuel is more. In hills, fire moves quickly in the upward direction and slowly in the downwards direction.

Now by observing the meteorological data and availability of fuel HAPS can identify and designate the fire-prone areas, So that locals can take preventive measures and authorities gets the data to act proactively. If there is a wildfire then by analyzing data like wind movement and where the fuel is more, HAPS can find where the fire is more vulnerable and where to send a fire-fighting team on time so that a small area fire does not turn into a disaster.

To prevent a small fire from becoming a wildfire we need 24*7 continuous monitoring which only HAPS can provide.

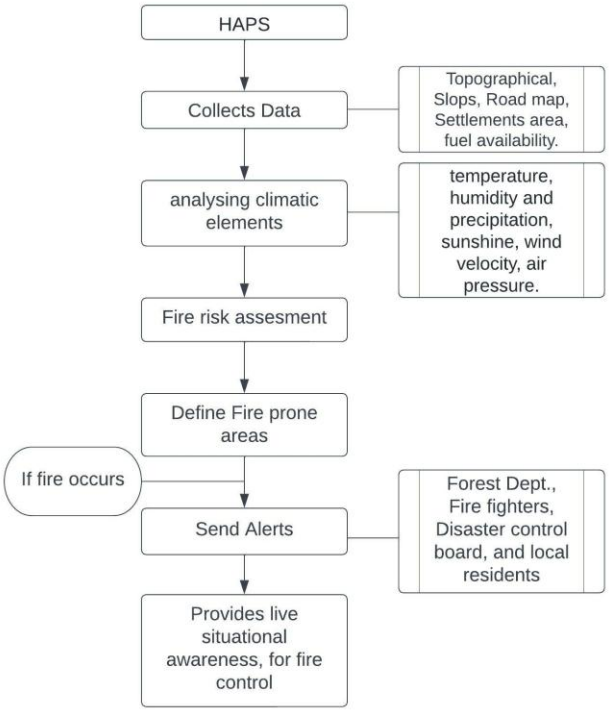

Fig-4: methodology for forest-fire detection & control by HAPS

3.3 Monitoring on-duty Forest guards/rangers

Monitoring on-duty forest guards/rangers whether they are on the field or not during their work hours, because they are the only people authorized to protect the forest and make sure that no one is able to do any ill-legal activities. If they are not on the ground, then just detecting ill-legal activity and forest fire using drones and HAPS will not be going to protect the forest. To ensure the security of the forest we must have boots on the ground. So here HAPS will not just track them and send their location to the command and control centre but can also provides situational awareness and seamless connectivity for real-time communication.

4. CONCLUSIONS

In the field of remote sensing/Earth observation, drones provide high resolution and accurate data but they have a drawback of less endurance (a few hours). Whereas geostationary satellite has the ability to continuously hang around a fixed location with the drawback: they are unable to provide high-resolution imagery. Which makes both these platforms unworkable for 24x7 monitoring purposes.

High-Altitude Pseudo-Satellite can do persistent surveillance over the designated area for months at the fraction of the cost of the Earth Observation Satellite. For those countries, that cannot afford to have Earth Observation Satellite, for them HAPS will be the best available option. In forestry, HAPS will work as a silent weapon against Poachers, timber mafia, and smugglers.

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