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Novel Umbrella 360 Cloud Seeding Based on Self-Landing Reusable Hybrid Rocket

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Abstract. Receiving sufficient rainfall has always been an issue in agriculture, wherein some areas receive a good rainfall while other areas receive no rain at all. Drought areas suffer an increase in temperature with extreme pollution and disturbance in plants respiration process. Moreover, the agricultural produce is poor and affects the farmers finances in a big way. On the other hand, whatever produce is available, turns out to be less affordable for the consumers to buy. State-of-the-art Cloud-seeding methods have been adopted before but are costly, less effective, and risky and time consuming. In this paper, we propose an umbrella-based 360 degrees design of a self-landing hybrid rocket to aid cloud-seeding and shall prove to combat the above-mentioned problems in an effective way.

Keywords: Artificial rain, Cloud seeding, Self-Landing, Hybrid rocket, 360 Umbrella mechanism.

1 Introduction

Rain forms as moisture accumulate around particles in the air like dust sand, making the air to reach a point of saturation at which it can no longer withstand the weight in that moisture and droplets fall in the form of raindrops. Cloud seeding is the dispersion of substances into the air (clouds) that serve as cloud condensation or ice for weather modification that aims to increase precipitation by altering the cloud composition. Water is one of the most basic commodities on earth sustaining human life. In many regions of the world, traditional sources and supplies of groundwater, rivers and, reservoirs, are either inadequate or under threat from ever-increasing demands on water from changes in land use and growing populations. Only a small part of the available moisture in clouds is transformed into precipitation that reaches the surface. This has made scientists and engineers for implementing the idea of cloud seeding and increasing water supplies i.e. rain making. Cloud seeding accelerates this process in providing an additional nucleus around which water droplets can accumulate and condensate.

1.1 Background

Cloud seeding techniques are new in India and not used much in the country presently. Although some experiments have been performed, none have shown success. There are areas where heavy rain has destroyed several parts of Maharashtra for some 6-7 years. But ironically from the past 2-3 years, these areas are declared as drought areas. The artificial rain process started many times with probably less success rate or even failed. The Nashik project [1] [2], where rocket-based cloud seeding technique was used, a total of five rockets were used, but eventually, only two rockets hit the target and were not enough for the satisfactory rainfall. This technique was firstly used in Maharashtra in India. While for another project in Aurangabad district (Maharashtra), four of 'king-air B-200' plane [2] were arranged to carry the silver Iodine along with Doter radar were imported from America for the cloud-seeding. Though the experiment was completed, the result-oriented goal for this technique was not satisfactory and was expensive for further trials.

The southern states became the most recent try with the cloud-seeding to bring back the rain as it was the third consecutive year that seasonal monsoons have failed in these regions resulting in drought hitting Karnataka [3]. Mass migrations and farmer suicides and the problematic agricultural scenario in the state. Though cloud-seeding programme has been approved in Karnataka [4] for cloud seeding program for the cost of Rs 88 cores further approved by the cabinet at 93 crores including other costs [4] but being a plane-based seeding process, it is expensive and time-consuming. From this, it though seems that there are implementations of various cloud seeding projects but none of having proper, legit and satisfactory results. It is evident that the cloud-seeding method adoption is at an amateur stage in India and if achieved it would be a milestone in the history of India.

1.3 Motivation

We can create endless solutions for water management but the fact is the availability of water should also be there. Around 2050 [5], India will face a huge and serious problem of water scarcity which will turn things to worse and we cannot afford to stay still and do nothing. Not only that increasing pollution, temperature, but drought and disturbance in water cycle is also creating a problem that was not faced earlier. Cloud seeding is not the exact solution but it covers a huge part in bringing balance in the water cycle and creating a chain reaction of reducing above mentioned problems.

2. State of the art

There are several cloud-seeding methods listed in the literature. Following are some cloud-seeding approaches:

a) **Plane-based cloud seeding:** Flares that produce small salt particles are attached to the trailing edge of the wings of seeding aircraft and ignited in updrafts below

the cloud base of convective storms. This method overcomes most of the problems and difficulties faced in the handling and the use of hygroscopic materials, difficulties that made seeding with ice nuclei (AgI) a more attractive option [6] [7].

b) **Drone-based cloud seeding:** The "Sandoval Silver State Seeder," a new drone built by the Desert Research Institute[8] which deploys silver-iodide flares to kick off rainfall. The cloud seeding drone just had its first test flight in the USA. It didn't form any rain but it only went 400 feet up. Cloud-seeding isn't really about creating weather from nothing, but more about getting it to fall when and where we want it, it's not for ending droughts.

c) **Ground generators:** It is known that ground-based generators are widely used in the world practice of weather modification for cloud seeding with the purpose of precipitation enhancement and hail suppression. In particular, in the United States, Morocco, Cuba, and many countries ground generators are used to increase precipitation, while in France, Spain, and Brazil for anti-hail protection [9]. Taking into account that the use of ground-based generators sometimes economically more expedient than the use of an airplane or rocket technology in 2005 began to create ground-based and firework ice-forming aerosol generators [10] [11].

d) **Electric Rainmaking Technology**: The ion technology's backers think their idea beats [12] cloud seeding for a number of reasons. It produces more rainfall, and it doesn't need clouds to be in the area to work. Also, it expects to be less expensive theoretically, because it doesn't require aircraft to spread chemicals, the usual method. Further, they believe that changing the polarity and quantity of the ions could reduce rainfall where it's too plentiful, prevent hail, and even break up fog at airports [12]. To these claims, Earth wise adds that its technology reduced air pollution [13] [14] in trials in Mexico City and Salamanca, because the condensation it caused warmed the air, creating an updraft that carried away pollution [14].

e) **Rocket-based cloud seeding:** Countries like China and companies or agencies are using rockets an innovative network of artificial intelligence-enabled strategic micro-rocket launches and a distributed grid of climactic sensors and spreading technologies for cloud seeding. Like ACAP’s Striyproekts the "LOZA" missile protection system is designed for active impact on clouds by spraying chemical reagent in them and consists of [15] [16] [17].

f) **Laser technologies:** Laser-induced [18] condensation has been recently proposed as a possible alternative to more traditional rain enhancement techniques like hy-

groscopic [19] and crystallizing seeding, due to its potential for triggering condensation in sub-saturated conditions. Although condensation has been shown to occur on very local scales by the use of lasers to generate CCN in sub-saturated air, questions remain on the relevance of this technology to precipitation enhancement and, thus, the approach is currently lacking the scientific basis to enhance precipitation in the atmosphere [9] [20].

g) **Acoustic waves:** A hail or acoustic cannon is a shock wave generator [21]. This shock wave then travels at the speed of sound through the cloud forming above; a disturbance which manufacturers claim increases collision coalescence growth of tiny water droplets, thus producing bigger raindrops. The cannon is also claimed to disrupt the growth phase of hailstones. Review the application of cannons to weather modification, and they find no scientific basis for this methodology.

The recent works done for predicting weather conditions using basic application sensors on factors such as humidity, temperature, the wind gives an overview of initiation of weather and its upgradation with time and environmental conditions [22]. Various modeling methods using liquid CO_2 uplifting the rain formation and finally the total rain [23]. Nevertheless, various inputs have been provided in past years is setting platforms for future development in weather enhancement methods.

Its applications is in the area of Agriculture and Environment countering various inputs and solution to various serious problems like Drought control [24]: Long and continuous process cloud seeding program can decrease the impact of drought in slow steady manner, however, since increased precipitation before and after drought would temper the reduction of rainfall during the drought period. It can be used for long water management. Creates rain (providing water) [2] [9]: India has made developments in providing well-sanitized water supply for the masses but as the population is increasing its resources are getting endangered.

Regardless of improvements to drinking water many water resources are getting polluted. In addition, water scarcity in India is predicted to worsen as the overall population is expected to increase to 1.6 billion by the year 2050. In further addition to these problems, water crises are ready to be a global concern.

i. **Pollution control:** As rain droplets fall, it acquires or attracts aerosol and carbon particles along with it bringing it to ground [12] [13], cleans the treas making he respiration of plans effective. Thus, controls the pollution
.

ii. **Temperature control:** Rain and temperature has opposite relation apart from humidity, rains bring the temperature down as the clouds shield the direct sun

rays landing on land creating artificial shed making the temperature fall which in fact decreases further as the cool water droplets bring the temperature down to a suitable temperature, this may result in a cooling effect for the Earth. Some scientists may seem this as a potential benefit, as this cooling may offset the warming caused by climate change. Eg. Dubai had a successful artificial rain project last year and opting to next project controlling temperature and pollution.

iii. **Hail suppression** [24] [25]: In order to prevent hail damages, it is necessary to transform the dangerous convective clouds so as not to allow the formation of large hailstones. The number of ice crystals in the cloud is small and, in the presence of appropriate conditions, they grow rapidly to hailstones with increased in size.

For an example, in a working model, Dubai has invested $11million [26], $168 million by China [27], $ 15million by USA [28], estimation of 10million (plans) by India [4] and few by other countries. All these cloud seeding projects include seeding by drones and mostly by planes making it immensely costly and inefficient to be precise.

3. Umbrella 360 Cloud-Seeding Approach: The Proposed Concept

The Umbrella 360 cloud-seeding approaches an Omni-directional 360 seeding technology (mentioned below the report) which means its uses 8 solid rockets seeders placed at a particular angle in a controlled launching mechanism (Fig. 4) (Fig. 5) with TVC (Thrust Vector Control) that proposes an idea of station keeping (hovering in air, refer to Fig 1) and a self-propulsion system. Its umbrella 360 seeding helps to increase the area of seeding changing angle (Fig. 6) in every single launch which automatically reduces the cost and increases rainmaking probability. While for drought areas we can target rain clouds [24] to move it to those regions to provide rain.

Fig.1 shows the trajectory of the rocket, how it launches, enters the cloud along with the hovering stage and finally with reaction control system helps to retrieve the rocket safely ready to be launched again. Fig.2 represents the launch land trajectory at different altitude level that defines slope ranges as:

O to A: Engine full thrust (take off) and gimbaling to overcome drag. At A: Max height for Engine offline. A to B: Inertial ascending till apogee. At B: APOGEE (max height). B to C: RCS in action controlling the seeding activity and rocket /free-fall. C to D: Partial engine online to slow down the rocket and D to E: Final burnout for self-landing wrt RCS and landing legs online.

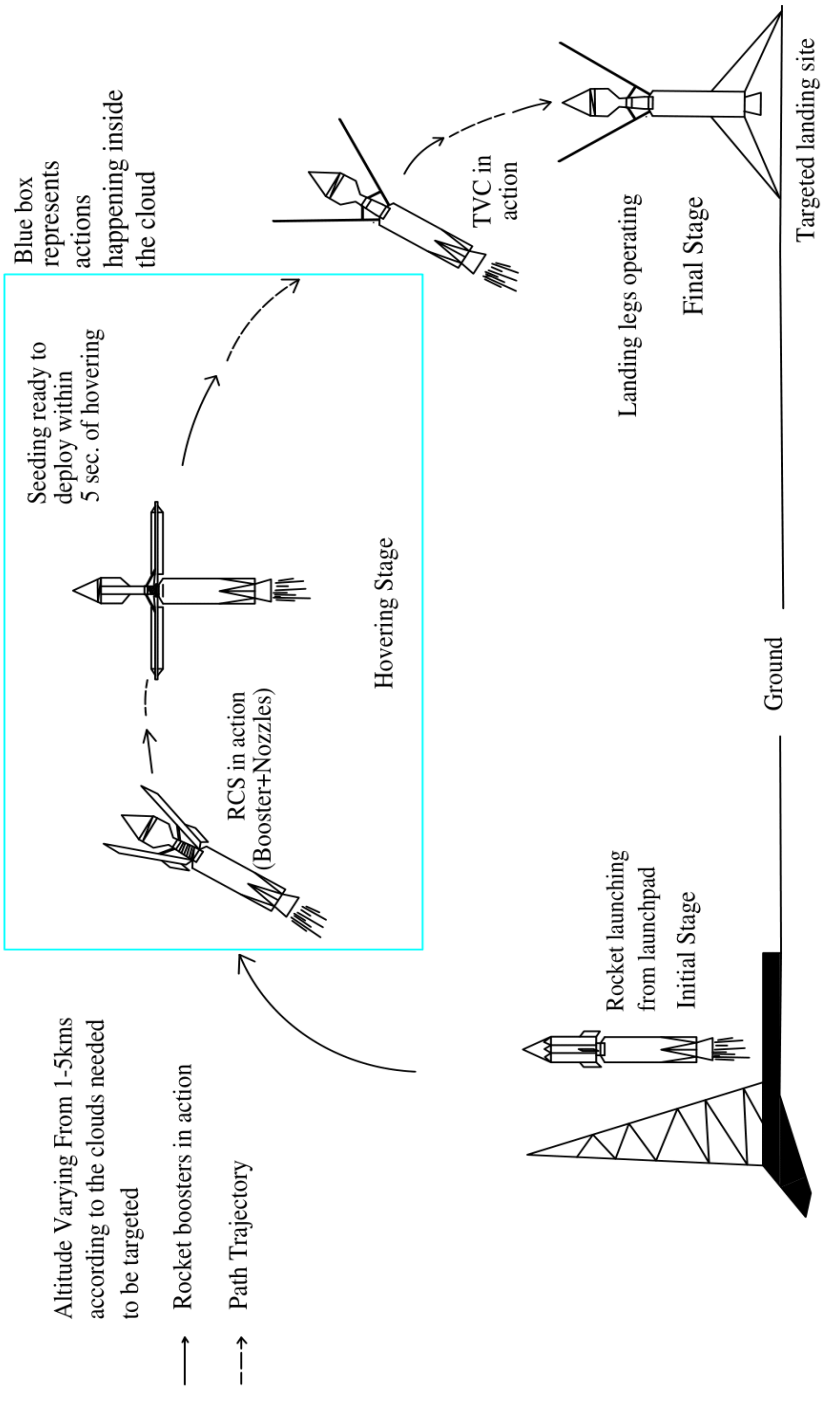

Fig.1. Rocket Launch-Land Trajectory

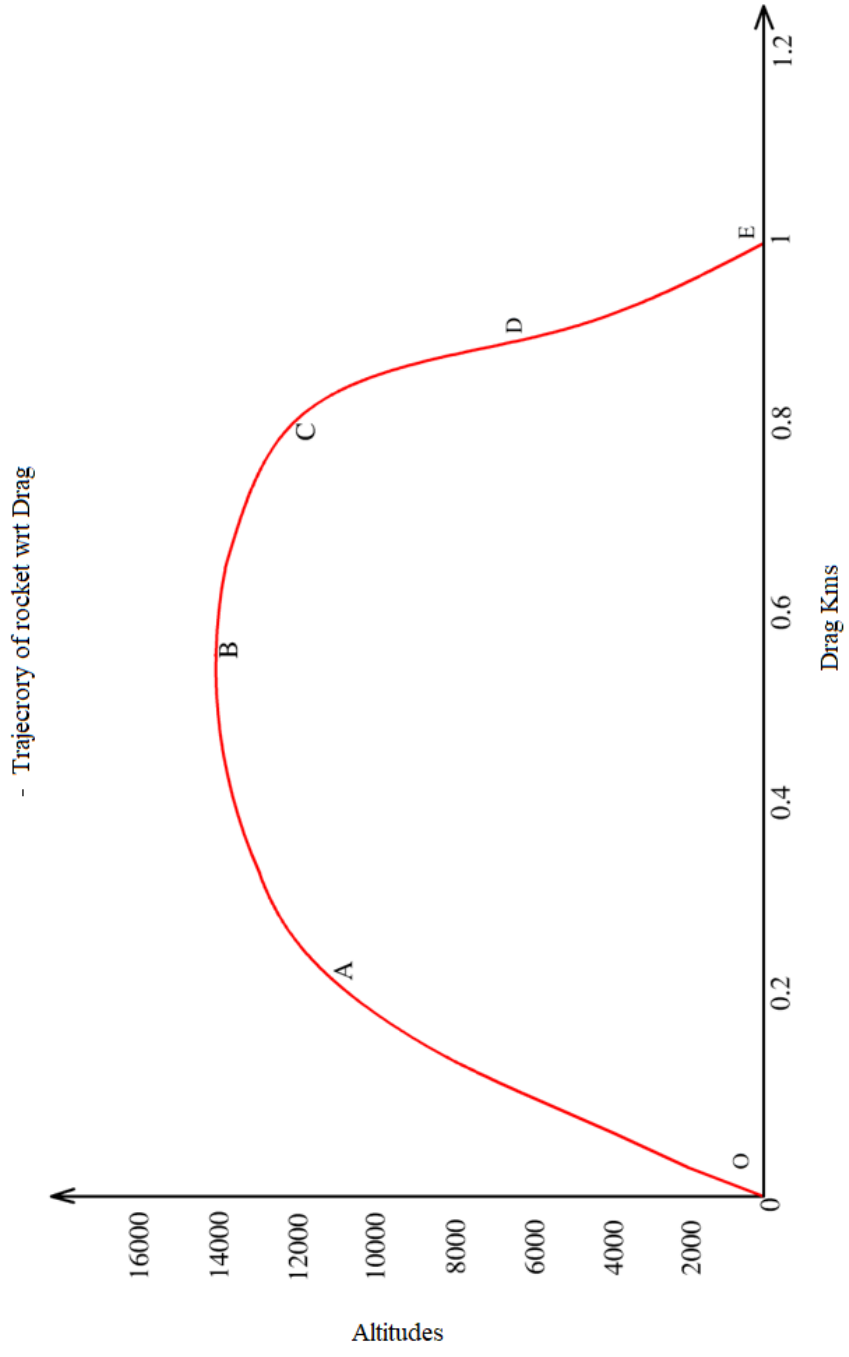

Fig 2: Rocket Launch-Land Trajectory for 2-5 kms

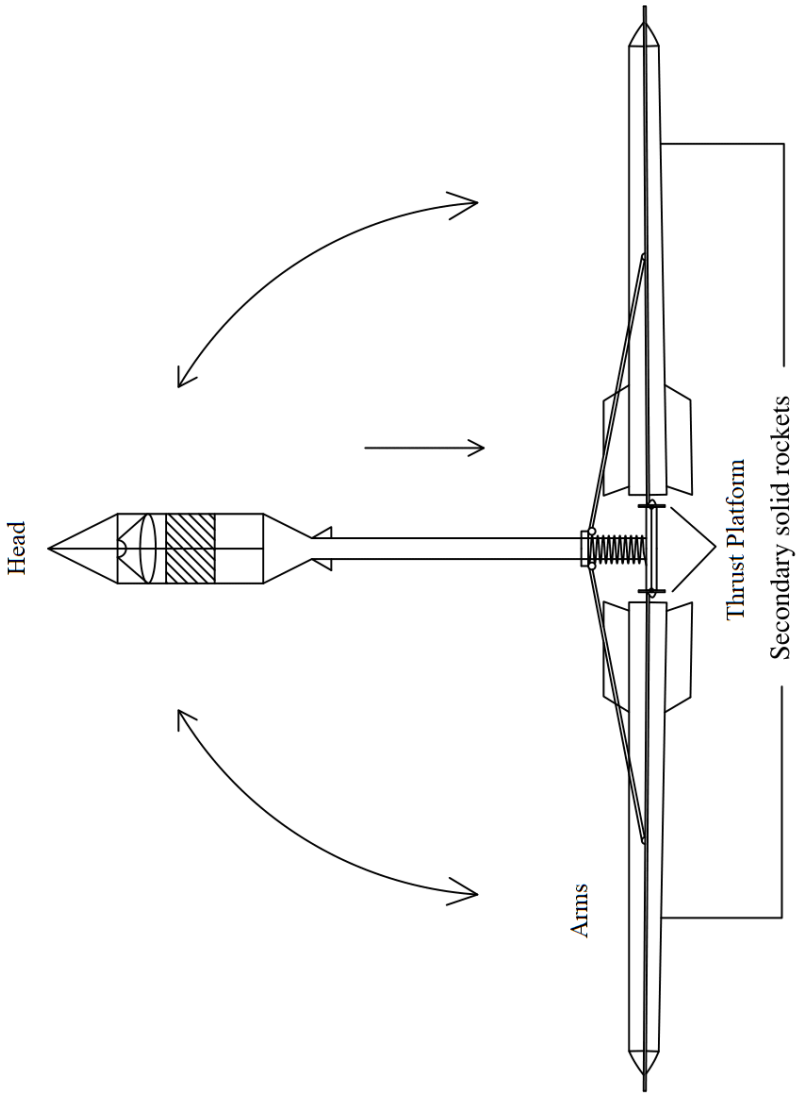

Fig.3. Umbrella mechanism completely open

Fig. 3 shows the umbrella mechanism opening which provides a takeoff platform to rocket seeders. 360-degree mechanism**:** The rocket places itself at the most probable center of the cloud and ejects the seeders in 360 degrees covering a large diameter of clouds in single takeoff, while the plane covers 1 km it covers 4 kms. This also includes angle spreading which ensures every part of the circular area is covered by changing its angle that the previous.

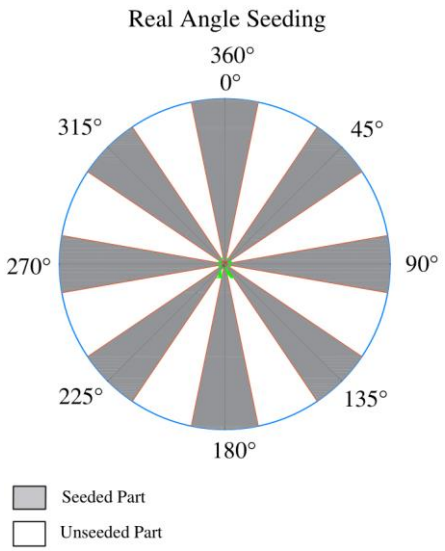

Fig.4. Real angle seeding

Fig. 4 shows the first launch covering angle that covers a part of the whole circle that according to the planned seeding cycle.

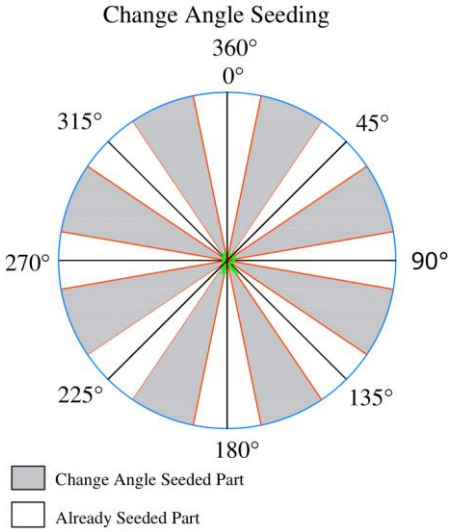

Fig.5. Change angle seeding

Fig. 5 depicts that each launch covers different area by just changing the rockets roll seeding angle targeting the remaining part of the circle of seeding cycle.

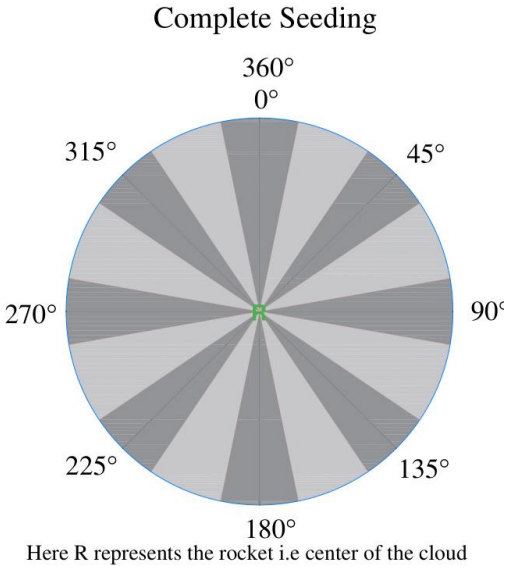

Fig.6. Complete seeding

Lastly, Fig. 6 describes that after each launch covering different area of the cycle dense the seeding coverage thus increasing the probability of rain formation, this automatically increases the seeding area and the probability of the rain making [9].

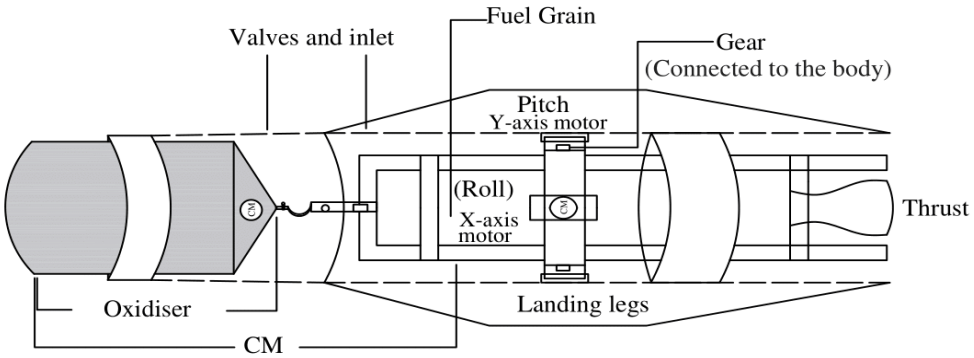

Fig.7. Self-landing mechanism

Fig. 7 illustrates the landing mechanism where the upper part is the oxidizer (N_2O/O_2) and the lower part is solid fuel embedded in a gyro mechanism that enables it to maneuver independently supported by two independent motors controlling pitch and yaw of the rocket nozzle that helps it to control its acceleration, deceleration and position decision with onboard gyro sensor.

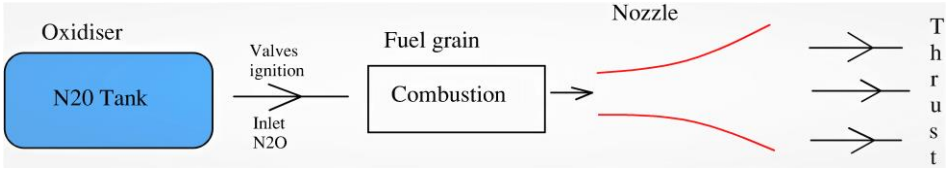

Fig.8. Oxidizer and engine workings/flow

Fig. 8 illustrates the rocket fuel and oxidizer flow layout (how the engine works). In simple words, as the oxidizer gets released into the fuel through an inlet, there is a chemical reaction occurring, by the insertion of ignition, it catches fire (starts to burn) because of excess oxygen provided by the N2O tank. The energy gets released in the form of thrust that results in forwarding acceleration if the rocket.

4. The Business Aspect

Along with its problem-solving potential it is also a good business idea. It holds up a market estimated to 300-500 million dollars [26] [27] [28] globally with conventional methods and as the technology improves things start taking a new shape expanding the business to huge levels, perhaps a billion dollar industry. This speculation is just for cloud seeding applications. It takes a phase shift as we include drought control, pollution control, hail and snow suppressions, and early acidic rain for preventing crop damage.

A market that huge, automatically creates costumers i.e. Government bodies, and contractors. This exactly creates a direct relation for costumer willing to pay versus criticalities which ensure 100% business growth with no delays or problems. This can be achieved either by boot strapping or potential funds by government or by investors increasing the valuation of the business along with demand. The below figure shows the area of business potential TAM: Total Available Market, SAM: Serviceable Available Market, SOM: Serviceable Obtainable Market

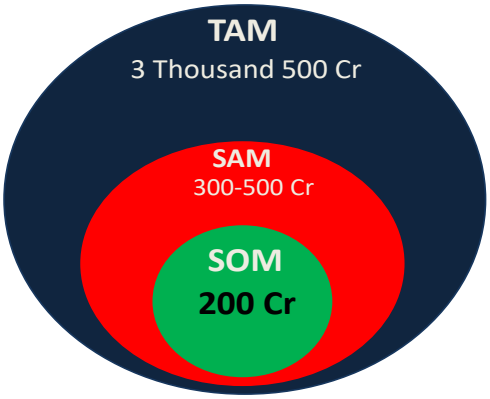

Fig. 9. Market Analysis

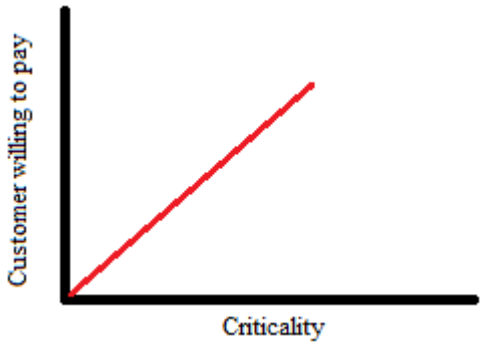

Fig.10. Comparison between criticality and customer willing to pay

Fig. 10 reveals the relation between criticality and customer willing to pay, as there will be scarcity of water in almost every region people (customer) will be ready to pay any legit price to get solution the problem occurring.

5. Conclusion

To obtain a sumptuous and healthy agricultural produce, it is essential to have sufficient amount of rain. Farmers struggle to fight with mother nature and suffer in obtaining a good and healthy crop yield especially in draught-hit areas. This paper proposed a solution of a 360-umbrella mechanism of cloud-seeding using reusable, hybrid and self-landing rocket in developing an eco-friendly, sustainable and a fair option with reusability advantages to combat the agricultural problems in areas receiving less or no rain. We describe the launching and landing trajectory of the hybrid rocket and discuss the 360 degrees omni-directional cloud-seeding method with suitable diagrams. Lastly, we conclude the paper by discussing the business aspect of adopting the cloud-seeding method.

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