# UNMANNED AERIAL VEHICLES FOR SPACE EXPLORATION

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**Abstract—** Space exploration is the on going discovery and exploration of celestial structures in outer space by means of continuously evolving and flourishing space technology. The study of space is not only carried out by astronomers with telescopes but also the space exploration of space is conducted both by unmanned drones and human spaceflight. Astronomy is said to be the observation of objects in space with an authentic and definitive history, but the 20th century led to the development of huge and comparatively efficient rockets which transformed physical space exploration into reality. Common hypothesis for exploring space includes advance scientific research, uniting the nations, ensuring survival of humanity and developing military and deliberate advantages against other countries. Space exploration has often been used as a proxy competition for geopolitical rivalries among countries such as the Cold War. This paper content deals with the role of unmanned aerial vehicles on earth and the future directions for the use of UAVs in space for exploration and observation purpose. The first half of the paper will deal with a brief study of UAVs and their role in various fields and the second half with the advancements that can be made in order to achieve accomplishment of tasks with no risk.

**Keywords—** Research, space exploration, spaceflight, UAV, unmanned robotic probes.

## I. INTRODUCTION

While we have been waiting for the future to come, the future is happening right now. For the past 200 years we have witnessed two great innovations in this field: the Industrial revolution and the Internet of Things. The former deals with electricity, factories, machines, railways, and changed our lives to an incredible extent. The Internet of Things led to Big Data networks, the computing power, interminable access to information and communication, thus serving as a tremendous breakthrough in our work and life.

Formally, drones are regarded as unmanned aerial vehicles or UAVs. Drones can be considered as “flying robots.”We know that, the aircraft can fly autonomously, thus being controlled remotely by software-developed embedded systems, which can operate accordingly with GPS or Global Positioning System. Drones are commonly used for the military purposes. In addition, drones are also carry out the operations of rescue, search, traffic, surveillance, exploration , forecasting and weather monitoring purposes, and much more.

The acronym UAV is used for Unmanned Aerial Vehicle which consists of no pilot on board. A UAV can be a remote controlled aircraft (e.g. flown by a pilot present at ground station) or can fly autonomously using pre-programmed flights or more complicated dynamic automation systems. UAVs are currently used for many missions, including reconnaissance and attacking roles. To distinguish UAVs from missiles, a UAV is defined capable of being controlled, sustained level flight and powered by a jet or reciprocating engine. In addition to this, a cruise missile can also be considered as a UAV, but is regarded separately due to the reason that the vehicle is the weapon. The acronym UAV has been expanded in some cases to UAVS (Unmanned Aircraft Vehicle System). The FAA has adopted the acronym UAS (Unmanned Aircraft System) to reflect the fact that these complex systems include ground stations and other elements besides the actual air vehicles.

Officially, the term 'Unmanned Aerial Vehicle' was changed to 'Unmanned Aircraft System' to reflect the factor that these systems include ground stations and many other elements besides the actual air vehicles. The term UAS, however, is not widely used as the term UAV has become part of the modern lexicon. Using bats to carry incendiary bombs into enemy territory wasn't a good idea, and it wasn't a bad idea in the history of unmanned aerial vehicles (UAVs). During the American Civil War, an inventor proposed an unmanned balloon for carrying explosives that could be dropped after a time-delay fuse mechanism which could trigger the basket to overturn its contents. Air currents and weather patterns made it difficult to estimate for how long to set the fuse, and the balloon was never successfully deployed. By 1883, the first aerial photograph was taken using a kite, a camera and a very long string attached to the shutter-release of the camera. In 1898, this technology was put to use in the Spanish-American War, resulting in the aerial reconnaissance photographs.

As the possibilities and capabilities of all types grow for UAV, nations always try to subsidize their development and research leading to advancements enabling them to perform a assemblage of missions. UAV these days no longer perform only intelligence, and reconnaissance (ISR) missions, although it will still remain their predominant type.

Their roles have even been spreading to areas such as electronic attack (EA), strike missions, suppression and/or destruction of enemy air defence (SEAD/DEAD), network node or communications relay, combat search and rescue (CSAR), and derivations of these themes. These UAV cost ranges from a few thousand dollars to tens of millions of dollars, and the aircraft used in these systems range in size from a Micro Air Vehicle (MAV) weighing less than one pound to large aircraft weighing over 40,000 pounds.

## I. ROLE OF UAV'S

UAVS – EVOLUTION OF UNMANNED AERIAL VEHICLES

The term unmanned aerial vehicles (UAVs), at present , effectively points our attention towards the military utility vehicles controlled without an on board aircrew. However the applications of such kind of objects is not only limited to the military use as oil fields surveys and general purpose surveillance have also employed UAVs as an iconic tool for flourishing their business. The UAVs we see today, have evolved through an iterating process similar to those developed some ninety to hundred years ago were simple and of basic type, owing to the fact that technology wasn't that much advanced as it is today. The type of UAVs first known to world were balloon shaped were mainly used to carry some weapons to the enemy's territory and could intelligently activated to accomplish the assigned mission from a remote end. This was the modified war strategy used in world war one, however not hundred percent successful. To alleviate the limitations of formerly developed UAVs and to augment the level of intelligence of the vehicle, efforts were made after world war one era to develop aerial torpedoes which had ultimately led to cruise missiles used in the next world war. Most importantly there are two major forms of UAVs i.e. Intelligent missiles and Drones and to distinguish these two the factor is the type of mission and recovery of the vehicle. The former type is used for destruction purposes only and the later one is primarily based on surveillance and reconnaissance and the vehicle is recovered after mission.

With time, the second form found has been divided into three major categories known as

1. Nonlethal UAVs which are used only for espionage and surveillance purposes.
2. Unmanned combat aerial vehicles which along with surveillance cameras are also capable of carrying ammunition to hit the target with pin point accuracy.
3. as Pilotless aerial systems like target drones which are used for training purposes only

Uav types

Target and decoy - providing ground and aerial gunnery a target that simulates a rival aircraft or missile

Reconnaissance - provides battlefield intelligence

Combat - attacking capability for highly-risky missions (see Unmanned Combat Air Vehicle)

Research and development - used for further development of UAV technologies to be integrated into field deployed UAV aircraft

Civil and Commercial UAVs - UAVs specifically designed for civilian and commercial purposes.

Degree of Autonomy

Some early UAVs are also known as drones because they are as sophisticated as a simple radio controlled aircraft being controlled by a human pilot at all times. More sophistications or new versions may consists of built-in control and guidance systems to perform minor human pilot duties such as speed and flight path stabilization, and simple prescribed navigation functions such as waypoint following. From this point of view, most early UAVs were not at all autonomous. In fact, the field of air vehicle autonomy is a recently emerging field, whose economics is largely controlled by the military to develop war ready technology for the warfighter. The market for autonomy technology is fairly undeveloped when compared to the manufacturing of UAV flight hardware. Because of this, autonomy may continue to be the bottleneck for future UAV developments, and the overall rate of expansion of the future UAV market could be largely taken over by advances to be made in the field of autonomy.

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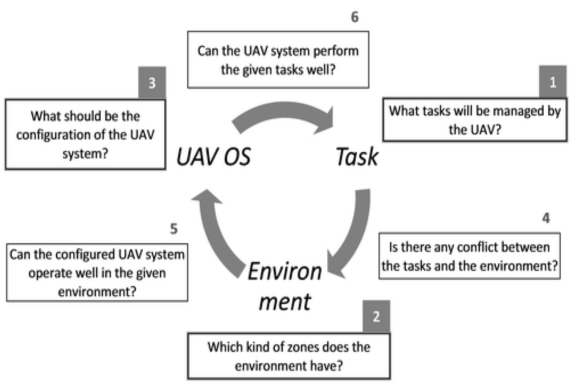


Autonomy technology will always be important to future UAV development and will falls under the following categories:

Sensor fusion: The information from different sensors is combined for use of vehicle on board.

Communications: To handle coordination and communication between multiple agents in the presence of incomplete information

Motion planning or Path planning: To determine a favourable path for vehicle to go while dealing with certain objectives and constraints, such as obstacles

Trajectory Generation: Determining an optimal control maneuver to take to follow a given path or to go from one location to another

Task Allocation and Scheduling: For the optimal distribution of tasks amongst the agents, with timing and equipment constraints

Cooperative Tactics: To formulate an favourable sequence and spatial distribution of agent activities in order to increase the rate of success in any mission scenario Autonomy may be commonly considered as the ability to make decisions without the intervention of humans. To that end, the goal of autonomy is to teach machines to be "smart" and act more like humans.

**UAV Endurance**

Because UAVs are not burdened with the physiological limitations such as human pilots, they can be designed for maximized on-station times. The duration of maximum flight unmanned aerial vehicles differs widely. Internal combustion engine aircraft endurance strongly depends on the percentage of fuel burned as a fraction of total weight (the Breguet endurance equation), and hence is largely independent of the size of aircraft. Solar electric UAVs hold the potential to carry out unlimited flight, a concept championed by the Helios Prototype, which unfortunately was destroyed in a 2003 crash. While UAVs receive only a fraction of the amounts spent on fighter aircraft and tactical missiles, large U.S. requirements spurred by the War on Terror have changed the picture. Throw in aggressive submarine and ship-launched UAV programs, a future UAV roadmap, and the high cost of advanced systems like the RQ-4 Global Hawk UAV (whose production over the next 10 years is expected to reach $3.5 billion and exceed 200 units) and J-UCAS, and the global forecast ends up getting a significant boost. Many people have mistakenly used the term Unmanned 'Aerial' System instead of Unmanned Aircraft System.

## II. ACHIEVEMENTS IN UAV FIELD MISSIONS AND TASKS

The new way of using UAVs in airpower will bring significant changes to the Air Force capabilities for the future civil and military operation structure. This change in the new era has enhanced unmanned vehicles development and \technologies in a top priority list for military combat and non-combat operations.

In order to achieve full potential benefits of UAV operations, and complete integrated communication systems, the military recognizes that it is essential to deploy family of UAVs and an operation system that comprises of large UAVs capable to deploy small UAVs to locations where manned or other UAVs are unable to access.

EQQUERA - “Mother Hen and Friendly Chicks” concept would have significant potential of successfully addresings the existing requirements of the family of UAV systems that are highly needed for Air Force missions. Specifically, enhancing the interlink network communication capabilities, and mission capabilities with merging systems of manned and existing UAVs.

One of the most important advantages of the EQQ UAV concept is that the Mother UAV is capable of carrying number of Sub UAVs, and these Sub UAVs have the ability to carry number of Mini UAVs, and perform as one big family than single aircrafts. This cluster of UAVs and individual platform capabilities would allow each of the UAVs to engage in multiple platforms and broad range of missions.

**EQQ UAVS CAPABILITIES:**

- Communication and navigation capabilities between EQQ UAVs, manned and existing UAVs
- Enhance the existing intelligence, surveillance and reconnaissance (ISR) capabilities by creating a combined interlink communication capability with manned – UAVs and EQQ UAV family, in various points of altitudes - high, mid and low, including surface, underground and undersea
- Access to complex and dangerous sites and critical areas
- Module of mixed various payload capabilities
- High survivability, and long loitering capabilities
- Refueling capabilities in mid-air

Civil Applications

- Humanitarian missions
- Arctic missions such as surveillance and protecting borders
- Arctic environment and scientific missions
- Combat oil spills in the Arctic
- Combat regional wildfires

## III. POWER SOURCES OF UAV

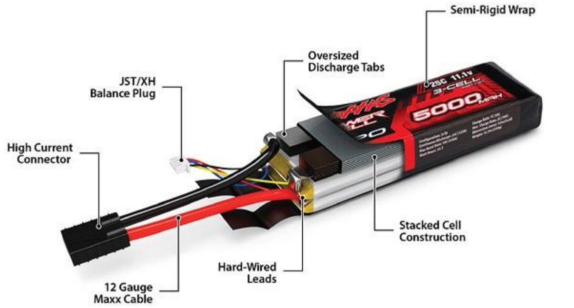
The vast majority of UAVs for public and civil use will be pered by advanced battery technologies. Some of the UAV technology based fuel engines are regulative .application specific but also expensive. Most of the public, hobby and civilian UAVs are powered by some kind of battery. Nickle Cadmium (NiCad) and Nickle Metal Hydrid (NiMH) were first used, but now

Lithium based batteries are commonly used. Llithium batteries are simple - really high energy density and hence are very popular. Lithium batteries let UAVs fly for at least a useful length of time because they consists of enough stored energy. The current rating of a battery is referred as the total energy available from the battery at its rated voltage. The cells are assumed to be only in series and not parallel and so the current rating is also the same as for each individual cell.

The rating is in mAh (milliamp hours) and is the available current that can be provided by the battery for one continuous hour. For example a 1000 milliamp hour (1 Amp Hour) for 1 hour battery will be discharged at 1 Amp. Batteries are composed of a series of cells from one to several which may be series or parallel connected. Individual cells or a single cell battery in Lithium Ion or Li Poly is anywhere from 3.2 to 3.7 volts depending on chemistry. For a given chemistry current capacity of may differ while the cell voltage remains the same. The same current capacity remains the same for all cells in a given battery. The current capacity will be the same if two cells are connected in series (positive to negative) while voltage will be double . Two cells in parallel (positive to positive and negative to negative) doubles current capacity but voltage stays the same. The batteries is an assemblage of a set of cells of the current capacity required which is wired in series to produce the required voltage. The acceptable discharge rate of a battery can be measured by multiplying its current rating with its C rating. Tthe battery will be discharged at the same rate as its capacity if the C rating is 1. So a 1 Amp (1000mah) battery with a Crating of 1 can be continuously discharged at 1 Amp. If the C rating is exceeded then this leads to damage and can cause the battery to burn or even explode.

LiPo batteries are normal lithium ion chemistries where the polymer separators reduce capacity but leads to higher discharge rates. By changing the physical and chemical nature of the separators, specific features of anode and cathode can be optimized. Though LiPo batteries are commonly used for UAV , the capabilities of Lithium Ion also need to be considered. The Panasonic Lithium Ion battery has almost twice the energy density compared to (Zippy) Lithium Polymer battery. The Panasonic supplies at least 25 percent more than a top of the line MaxxAmp Lithium Polymer battery. The Zippy Compact Pro LiPo battery performance is of most common use in our UAVs. MaxxAmp results in 25 percent longer flight times for the same battery weight when taken instead of Zippy Compact Pro. And if you can accommodate the Panasonic Lithium Ion batteries you can double you flight times with slow discharge rate.

Lithium Polymer




The popularity of Lithium Polymer battery is due to high discharge rate, and the square package fits in the UAVs. Lithium Ion _ Lithium Ion batteries has the major advantage that it has to twice the energy density of a LiPo. Some constraints are that they are always cylindrical and consists of a metal casing occupying little space and weight, but not much. But even with those constraints Lithium Ion batteries have more than 70 percent more energy density by weight than LiPos. LiPo batteries can also fail catastrophically due to external or internal short circuit or even due to physical damage and burn vigorously. They can even burn up without any activity in process, although this is less common now. The energy density available in LiPos will support flights from 10 to 30 minutes in copters an hour on airplanes.

This directly translates to 70 percent longer flight time . The Achilles heel of the Lithium battery is used for it's low discharge rate. Most currently used Lithium Ion batteries have a 2C Discharge rate and if drained above that rate can cause damage to the battery. That's the reason why Lithium Ion batteries now contain built in protection against charging or discharging too fast. But for our use this means that if you need more power than the battery ratings , it simply won't provide it. If you are flying a multicopter and a motor has to speed up to provide stability and if the power is not available you have a problem. Or if your airplane requires more power than is available, this will pull down the electronics and servos such that they won't function. Nonetheless, the high energy density clearly specifies designing UAVs that can work within the Li Ion discharge envelope. An airplane could get up to two hours with lithium ion batteries while a copter could get 40 to 60 minute flight times. A secondary advantage of lithium ion batteries is that if properly taken care they can operate to over a thousand charge cycles.

## IV. CHALLENGES IN SPACE EXPLORATION.

Affordable Abundant Power: Today's space explorations are limited by the considerations of mass and lifetime in the specific missions. Current power system gets degraded over time in the spacecraft, thus as the mission progresses the amount of power available gets reduced. Efficient use of space based resources is critical for NASA's future missions of science and exploration.

Surviving Extreme Environment: The machine operations and survival are affected by extreme environments present during space travel. Like humans, machines are impacted by gravity, propulsive forces, radiation, gases, toxins, chemically caustic environments, static discharge, temperature variations, dust, extreme temperatures, and more.

The goal of exploring a wide range of targets can be achieved across our solar system only with the ability to survive extreme environments.

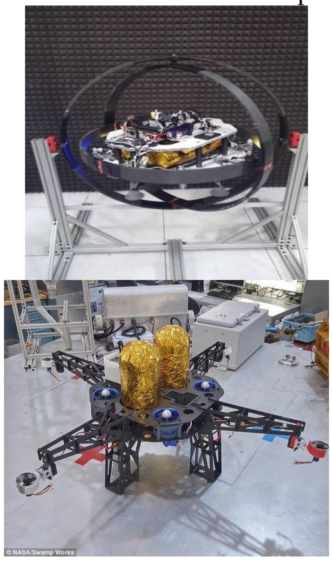
High Mass Planetary Surface Access: The challenging operations are entry, dive and landing. A space system must be robust enough to withstand a wide range of hazards associated with uncertain position and velocity knowledge, atmospheric conditions, aerodynamic loading, heating, particulates, and terrain characteristics to safely arrive at a destination.

Transportation Efficiency: To travel to a particular destination the ability of spacecraft should be a function of the laws of orbital mechanics, mass, and propulsion system efficiency. Human and robotic exploration demands transportation throughout the solar system and is limited by the performance of the propulsion systems these days. Economical Space Access: Today it costs about $10,000 to load a single pound of mass into low earth orbit. A vital part of this cost is associated with the design and production of the launch system. Nearly 40% of the total cost is due to ground and launch processing. The full lifecycle cost must be lowered by an order of magnitude to enable frequent human and robotic operations in space.

## V. Drones In Space

NASA has been building drones to explore the Earth and robots for other planets. Logically the next step: robot drones in space. NASA's Kennedy Space Center's new research shows that the agency is working on the possibilities to explore other planets and asteroids using UAVs that can fly to places its rovers can't access. Their design looks a lot like a traditional quadcopter. But in space, there is only vacuum unlike air on Earth, this means that we can't use the propulsion systems found in most commercial drones, as tiny propellers could not provide enough pressure through the thin atmosphere. So the team at NASA has created a system that putters around using cold-gas jets. The current testing is done on whether it can have the drone fly autonomously—similar thing has to be figured out for earthbound drones—or can it be operated by someone back on Earth. The drone has similar characteristics to that of NASA's rovers, to collect samples using a range of tools that it could change, depending on what are the current interests of the scientists on a given day. It is said to be a prospecting robot by NASA's senior technologist. The team's prototype drone is about 5 ft wide—which is more than double the width of the average commercial drone—but was built with "off-the-shelf components" and parts are 3D printed itself.

The team wants to deploy drones as an alternative to places which are not accessible by the rovers, like the inside of Martian volcanoes. A drone could fly into the crater of a volcano to set up a base making it a safe place for astronauts, away from the harsh elements. Engineers at NASA's Kennedy Space Center are inventing drones called as Extreme Access Flyers which are capable of withstanding the inhospitable conditions of space and carry out "hunt and gather" task from the inaccessible places.



NASA's homemade drone. (NASA/Swamp Works).

The machines are being built to survive the thin atmosphere of Mars, or the airless voids of asteroids and the moon. To replenish batteries and propellants among the flights, this type of lander spacecraft can be used and scientists envision that Extreme Access Flyers will be able to travel to shaded regions of a crater and pull out soil samples. Several models have been put forward by researchers to test aspects of the final machine. One model is a large quad-copter with ducted fans, which is about five feet. This is almost the size of the prototype which the team had in mind for a mission in space.

Small autonomous (or teleoperated) UAVs have permitted access to remote locations that are too dangerous, too difficult or too costly to send people, thus revolutionizing surveillance and warfare on the Earth by creating a perch for observation.

These small vehicles have proved to be remarkably robust and capable, motivating people to dream and design new ways to use them. Drone capabilities and properties would naturally attract the attention of the spaceflight community, as there places which are yet to be explored and characterized. Planetary surfaces showcase many exotic and interesting landforms, some hundreds of kilometers in extent, with features that would be greatly beneficial from prolonged examination from above.

Moreover, some areas such as vertical walls of scarps and cliffs are mostly inaccessible from ground travel alone, including the, the peaks of steep mountains, and the deep interiors of caves and voids in the subsurface. Such targets would offer many exploratory possibilities to hovering flights around such areas. The difference is that the atmospheric environment is easy to cope up with and well understood by terrestrial drones and hence they operate easily. The atmosphere permits small vehicles to hover and translate via the efficient technique of air displacement, where vehicle movement is supported by rotating propellers both laterally and vertically. This technique, with adaptations, can also work on Mars and Venus, as both planets consists of some atmospheres (one extremely thin and the other very thick).Without an atmosphere, it is not easy to support the mass of an “aerial” vehicle on the Moon, other than using some type of rocket propulsion.

Of course, such methods work, but rocket engines consume fuel at very high rates. This limits the flight timing available and hovering over the target of interest. The low gravity of the Moon is a plus—with less gravity, making hovering around target easier. But in general, flights across the Moon in such a manner will be limited by the indomitable tyranny of the rocket equation. When such formidable challenges are put forward for the construction of a lunar drone, there are those who have not shied from imagining the possibilities of flying vehicles to explore the Moon close up. One interesting concept was seen in a proposed mission to study lunar lava caves.

Mark Robinson, the Principal Investigator for the Lunar Reconnaissance Orbiter Camera, has put forward a mission he calls “Arne”. Arne consists of a soft landing spacecraft and three small “pit-bots”, spherical flying robots about 30 cm in diameter. The flying pot-bots after landing would traverse the side of chambers of the opening on the Moon’s interior, determining if the caves were created due to flowing lava and surveying walls.

The lander would go down inside the newly discovered lava pits investigated on the moon; from the bottom of one of the pits, there is a direct line-of-sight to Earth for communications. The flying pot-bots after landing would traverse the side of chambers of the opening on the Moon’s interior, determining if the caves were created due to flowing lava and surveying walls.. The flying pit-bots of Arne could use a lithium hydride and peroxide propulsion system that levitating the vehicle for short, one-to-two-minute hops.

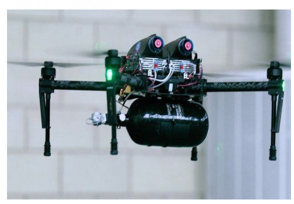
Images, magnetic information, and obstacle avoidance data are taken for the cave walls during flight. Two flying pit-bots can even be mutually support, based on their data given back to the lander, which can then be sent back directly to Earth. By using alternate hops of each pit-bot, survey of several hundred meters of an existing cave system can be done. These drone-like vehicles could be a relatively inexpensive way to explore lunar lava tubes.

## VI. POWER SOURCE FOR SPACE – FUEL CELLS

Producing power without damaging our environment is a continuing challenge. Fossil fuels like gasoline, coal, and jet fuel increases air pollution and harming the environment as they are not renewable. Batteries have a limited lifetime and hence have to be disposed of in hazardous-waste landfills. Most of the environment friendly fuel alternatives (hydroelectric, solar, wind and geothermal power) can be used only in particular environments. In contrast, fuel cells can have near-zero emissions, efficient, and can work in environments where the temperature is less than the cell's operating temperature.

A fuel cell is system that carries out the process of converting hydrogen and oxygen into water, producing electricity and heat. It consists of two electrodes, the negative anode and positive cathode, separated by an electrolyte that allows flow of specific ions. Fuel gets transferred to anode and oxygen to the cathode.A fuel cell combines a fuel (hydrogen or hydrogen source) with an oxidizer (oxygen or air) for producing electrical power. These devices work in a similar manner compared to batteries, but they do not run down or need to be recharged.

Like a battery, a fuel cell has two electrodes (a cathode and an anode) which are separated by an electrolyte. However, batteries have at least one solid metal electrode that slowly gets used up as electricity is produced. In a fuel cell, there is no consumption of electrode, and thus the cell can produce electricity as long as more fuel and oxidizer are pumped through it.



Fuel cells can use hydrogen directly, or they can obtain hydrogen from another fuel, like liquid methanol (wood alcohol), which is renewable and can be transported more easily than hydrogen. The byproducts possible with hydrogen fuel are heat and water. Along with these major byproducts, a fraction of the carbon dioxide and none of the other pollutants produced by a gasoline-burning engine while using methanol fuel. For human spaceflight , alkaline fuel cells have been used as primary source of electrical power for the past four decades.

However, alkaline fuel cell is a costly, aging technology. Before being operated at extreme altitudes and low temperatures much work has to be done for improved fuel cells. This technology will enable new space exploration missions as well as fuel savings, quiet operation, and reduced emissions for aircraft.

Current investigation is done on three types of fuel cells: proton-exchange-membrane fuel cells (PEMFCs), solid-oxide fuel cells (SOFCs) and regenerative fuel cell (RFC) systems. PEMFCs was first developed by NASA for the Gemini mission, but since PEMFCs had water-management problems, through the 1990s alkaline fuel cells were used. Improved PEMFCs promise to be more powerful, safe, light, simple to operate, and more reliable. Compared to current alkaline batteries, they last longer, perform better, and may cost much less. PEMFCs use hydrogen fuel producing only water so pure that it can be used as drinking water for spacecraft crews. NASA PEMFCs is also capable of producing electricity for spacesuits, airplanes, UAVs and reusable launch vehicles. In RFC systems, hydrogen and oxygen is used by fuel cells to produce electricity, water, and heat. Then a solar - powered electrolyzer breaks the water into hydrogen and oxygen so that the fuel cell can use it again. The waste heat is also used. RFC systems provide efficient, highly reliable, environmentally friendly, renewable energy conversion. Glenn researchers at NASA have developed on concepts of RFC for storing energy on the International Space Station, high-altitude aircraft and high-altitude balloons. Investigations on using RFCs for storing energy on the Moon or Mars. SOFCs are being recommended for power generation and for using in space due to their high power density, high efficiency and extremely low pollution. They have an all-solid construction allowing them to operate at high temperatures thus producing clean, efficient power from easy-to-transport fuels instead of pure hydrogen. SOFCs also are being developed for portable electronic devices, cars, and aircraft. Because NASA SOFCs has operate at high temperatures (600 to 1000 °C) for thousands of hours in corrosive environments, Glenn researchers combined the separator and sealant for developing special sealing materials. A novel process was developed to make SOFC parts that provide support for correcting fuel-flow problems but weigh less. Finally, they developed thinner, lighter, high-temperature interconnects that reduce the weight of the entire SOFC system. NASA Glenn's fuel cell is providing pathway to new flight capabilities, electric power for long-term human exploration beyond Earth orbit, more efficient cars and trucks, and a cleaner environment.

## VII. ADVANTAGES OF FUEL CELLS

One of the important use of fuel cells is to provide electrical power in spacecraft. Hydrogen-oxygen fuel cells have several advantages:1)they have no moving parts. 2)they are compact (small for the amount of electricity they produce). 3)they are lightweight. Most cars use petrol or diesel. These fuels are produced from crude oil, which is a fossil fuel. Like all fossil fuels, crude oil is a non-renewable resource – it takes a very long time to make but is used up faster than it is formed. The combustion of such fuels leads to the release of carbon dioxide, which is a greenhouse gas linked to global warming and climate change. The car industry is working on fuels cells to avoid these drawbacks. The use of hydrogen-oxygen fuels cells in cars has many benefits, which includes zero emissions of carbon dioxide from the car, and less dependence on fossil fuels. The Earth is made up of vast amounts of water, which can be decomposed - using electricity - to produce hydrogen. Apollo and the space shuttle both used hydrogen-oxygen fuel cells for electrical power. Two chemical components are combined at a controlled rate for emitting heat, electricity, and some chemical waste product. When it comes to hydrogen-oxygen fuel cells, the waste product is water, which is then used by the crew. Fuel cells require support equipment which adds on to significant weight and introduces potential failure modes. The two need to be stored in tanks, cryogenically for hydrogen and oxygen. The fuels are delivered to the fuel cells by plumbing and valves which could fail mechanically. The well-known failure of Apollo 13 was due to explosion of an oxygen tank supplying fuel cells and breathable air to the crew. This single failure severely reduced the supply of electrical power to the spacecraft and endangered the crew due to a limited supply of breathable oxygen. Fuel cells have a common advantage along with RTGs of operating without the requirement of sunlight, but the fuel gets consumed quickly. While an RTG is capable of operating continuously for decades, a fuel cell gets depleted in days under normal missions. Unlike RTGs, reaction rate of fuel cells can be controlled to limit waste heat.

and are made of safe materials.The poor energy-to-mass ratio of fuel cell systems may limit their applicability to near-Earth manned spacecraft, where a supply of oxygen is already needed and the waste water can be put to use.

## VIII. CONCLUSION

The concept of introducing unmanned aerial vehicles into space can work out dynamically in the field of space exploration as well as research. This can be possible by using fuel cells as an alternative power source to carry out long term tasks in space.

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