

The Drone Technology Wireless Charging Systems

Posted on May 12, 2020

Chapter 1: Introduction and Its Settings

Introduction:

The term UAV is abbreviated as Unmanned Aerial Vehicle, a flying machine with no pilot on load up. The UAV showcase is probably going to create incredible financial and innovative significance in the not-so-distant future due to the wide assortment of utilization and the additional esteem identified with these unmanned vehicles. For the last ten years, the creators of unmanned aerial vehicles have decided to think apart from the military industry and have exhibited compelling interest in powerful unmanned aerial vehicles in the common and business market. The military was the first sector who use unmanned aerial vehicles and exhibit UAV's efficiency and productivity, motivating other businesses or common sectors to use UAV systems. (Unmanned Aerial Vehicles, 2018)

General State of a Problem:

The latest technologies not only belong to aeronautics but also to other fields, which will significantly advocate UAV enhancements. This research is about the flight duration of the UAVs. The flight duration of UAVs (used for civil applications) is just 25 to 30 minutes. The flight duration is very low to carry out operations successfully. The drone performance is based on the weight of the power plant and the amount of fuel the UAV consumes, as these have a very prominent effect on the flight duration and range of the Unnamed aerial vehicle.

Objectives:

The following research has been conducted with the goal of investigating the techniques and technologies adopted to overcome the battery charging issues in drone technology. The battery-operated drones have very low flight duration to carry out operations effectively. During UAV's flight, batteries need to be replaced or charged. These are the obstacles in their smooth and elongated flight. The alternate solutions for manual battery replacement will also be investigated. A large portion of this paper consists of the wireless charging of UAV batteries to enable their smooth flight without any interruption.

The questions to be answered in this research paper are stated as follows:

“What apparatus autonomously can be used to address UAV’s manual charging requirements?”

“What strategic placement of the charging apparatus can increase UAV’s productivity and operation time?”

To answer the above questions numerous other questions are answered and further investigated:

- What is a drone?
- Classification of different types of drones.
- What are the issues regarding drone charging?
- What are the different methods adopted for battery replacements to elongate the flight duration?
- What is wireless charging methodology?
- How can [wireless charging](#) technology be implemented for drones?
- What kind of wireless technology will be developed in the future, and what is its ongoing work?

By answering the above questions, we determined what the drone technology is. The existing drone’s types and classification will be analyzed. Through the above questions, we will determine the issues regarding the batteries of the drones. We will identify the types of batteries being used and the maximum time taken by the drone to fly. We will further investigate the alternate methods adopted by different manufacturers to replace the batteries during the mission. This will further encourage to investigation of more effective solutions to battery charging or replacements. And eventually, by answering questions, we will investigate the most effective charging technology for the drone, i.e., wireless charging technology. We will also discuss the strategic placement of the charging apparatus to increase the UAV flight time and productivity. The future and ongoing technology developments regarding wireless charging will also be discussed.

Chapter 2: Literature Review

UAVs speak to a quickly developing action in business flying that will have an exceptionally significant financial effect sooner rather than later. The utilization of a few UAVs in performing common and business activities, for example, photography, natural life research and overview, agriculture looking over and mapping, and others, has animated the interest for UAVs in the business segment. The solid development of this market will join the expansion in functionalities, for example, higher continuance, bringing down commotion and outflows, and expanded mission extension, among others.

The drone framework comprises a three-hub gyro sensor, a three-hub increasing speed sensor, a GPS beneficiary, and an atmospheric weight sensor that measures the condition of the automatons, keeping in mind the end goal to steadily control the automatons, and the flight controller hereinafter alluded to as “FC” the control flag is transmitted to the electronic speed controller, which is an engine transmission, by mirroring the control calculation to the got working sign. The Electronic Speed Controller (ESC) drives the engine to control the development of the automatons because of an order

from the administrator, and all power sources are provided from batteries and the little unmanned airborne vehicles, for example, rambles are for the most part fueled by batteries, so flight times don't surpass 60 minutes.

In this way, after flying for a specific timeframe and coming back to the starting point of the flight, when flying after the charge, the drone comes back to the inception of the flight, the battery is devoured in time, and the battery is expended again while moving again in the wake of charging.

Because of this issue, the battery is expended amid the flight from the take-off point to the objective point as opposed to the time utilized for the drone to play out the mission. In this way, improvement of the charging framework to repay this is an important report for using the drone. There are numerous sorts of batteries, for example, Ni-Cd (Nickel-Cadmium), Ni-MH (Nickel-Metal Hydride), Li-Fe (Lithium-Iron) and Li-polymer, yet the most appropriate battery for Drone or Multi Copter is lithium polymer (LiPo). The polymer battery is marked 1 Cell or 2S, has a 3.7V voltage for each cell and can be worked in parallel yet not in the arrangement.

The unit of the release rate of the battery is indicated by C, 1C implies that it can yield one time of attractive limit. If the battery is 15C of 3S 2200mHA, it can yield 15 times and can be released up to $2200 * 15 = 33A$. The charging framework is outlined as though the voltage drops then the control circuit must be worked in to ensure the battery. While releasing, warmth will be produced. If released more than the execution, the battery will warm up a considerable measure, and the battery will be harmed.

Time Duration Issues in Today's Drone Technology

The aim of this section is to provide an overview of the different categories of drones that are used nowadays, their flight durations, operational range, and other technical specifications and applications. The flight duration of drones depends upon their engine type and size. These critical features of drones will remain critical in the next generation of drone technology.

The main categories of drones are multirotor, fixed-wing, single-rotor, and hybrid designs. The nature of technology utilized to maintain the drone flight specifies the drone category. The looks of the drone vary according to the drone's flight and type. (THE 3 MAIN CATEGORIES OF DRONES AND THEIR ADVANTAGES & DISADVANTAGES, 2017)

Multirotor:

Multirotor rambles are the most prevalent kinds of drones that are utilized by specialists and experts. Normal uses of multi-rotors differ; however, they incorporate flying photography, video reconnaissance and looking over to give some examples.

On the off chance that you are hoping to get a little camera noticeable all around for a brief

timeframe, at that point, a multirotor is the approach. They give you substantially more control over situating and encircling the camera to get you that impeccable flying photograph shot.

Multirotors can be additionally ordered, given the number of rotors on the ethereal stage. Tricopters have three rotors, quadcopters have four rotors, hexacopters have six rotors, and octocopters have eight rotors. Quadcopters are the most prevalent and utilized.

Multirotors do have their drawbacks. The real requirement is the restricted flying time, diminished perseverance, and speed. They are not suited for long separation reviewing applications, mapping, or investigation. The principal issue here is that a large portion of the vitality, more often than not from a battery source, is utilized to keep the automaton in a steady flying position. At present multi rotors are just equipped for most extreme flying circumstances of 20 to 30 minutes with a negligible payload.

Fixed-wing drone:

Fixed wing rambles are one of the sorts of drones that utilize a similar rule that planes use to produce lift utilizing a wing rather than vertical push-creating rotors. The vertical lift is created as an outcome of the forward movement of the wing through the air, influencing this a more proficient method for producing vertical lift.

A fixed-wing ramble can cross long separations, outline regions, and remain inside near vicinity for purposes of intrigue. Alongside the more noteworthy push-producing productivity, settled wing rambles can utilize gas-fueled motors. The maximum flight time of the fixed-wing drone is 1 hour.

The fundamental disadvantage of settled-wing airships is their failure to dally more than one purpose of intrigue, which discounts them for taking airborne photographs and recordings. Propelling and landing settled-wing automatons can likewise be dangerous. To get them noticeable all around, you require a runway or a launch. To recoup the automaton, you will require a runway, parachute, or net to recuperate them securely. Just little automatons are appropriate for propelling by hand or midsection arriving in an open field.

Single Rotor Helicopter:

A multi-rotor utilizes various rotors to create vertical, yet a solitary rotor utilizes only one, alongside a tail rotor, to control the heading. Helicopters are exceptionally basic in keeping an eye on avionics; however, they are once in a while utilized as a part of the drone group.

Single-rotor helicopter rambles produce push all the more effectively finished multi-rotors and can be fueled by a gas motor for longer flight times. A bigger rotor turning gradually creates push all the more proficiently. This is the reason long continuance quadcopters have a substantial propeller width.

A solitary-rotor helicopter with long edges is more similar to a pivoting wing than a propeller. This outcome is the more prominent push producing proficiency.

On the off chance that the application requires floating an extensive payload, for example, a LIDAR scanner, or you require a blend of long perseverance with forwarding flight, at that point, a solitary rotor helicopter ramble is great.

There is the downside of the expanded multifaceted nature, cost, vibration, and peril of huge turning cutting edges. Additional care should be taken to keep any damage caused by the turning rotor.

Fixed Wing Hybrids:

Another classification of hybrid UAVs that can take off and arrive vertically is being produced. These union the advantages of settled-wing UAVs with the capacity to float.

Some of these hybrid UAV ideas are settled wing plans with a vertical lift engine. Different outlines are tail-sitting flying machines that point vertically for departure before pitching over to fly on a level plane. Additionally, outlines highlight the rotor or the whole wing with propellers that can point upwards for departure and evenly for forwarding flight.

After studying different types of drones, the flight durations are analyzed. The flight duration of drones is usually low, and therefore, they are unable to carry out big operations. For fixed wing and multi-rotor drones, it is suggested to use gasoline engines to increase their flight time up to several hours. Lithium polymer batteries are utilized by multirotors; their flight time can be increased by using rechargeable batteries. Fuel cells can work well for more flight time as they are based on the principle of converting the chemical energy of fuel into electrical energy. However, due to their weight, they are adopted by few drone technologies. They work well with fixed-wing drones. Some studies show that the flight time of drones can be extended by using solar cells. But there are a few drawbacks of solar cells, which make them unstable sources because it is affected by the time of the day, weather conditions and locations. Another method to extend the charging of the UAVs is the stationary charging poles. In this method, the drones have to land on the charging poles to get themselves fully charged.

Chapter 3: Method of Investigation

The method of investigation related to drone charging issues and lower flight time is qualitative and conceptual (Qualitative Research Methods & Methodology, 2018). The approach can be categorized as an inductive approach to gathering qualitative data that mostly depends on the collection of documents and texts that are considered important to the particular topic being researched. The one aspect of the inductive approach is to be inclusive, broad and innovative in the information collection phases of qualitative research – and this especially is on the same wavelength with exploratory research. The information regarding our research has been gathered from a variety of documents and

texts produced by the media. Specifically, advertisement and article journals, newspaper and UAV-related magazine articles, drone technology research documents, brochures produced by drone vendors, drone technology websites, drone stakeholder websites, and wireless charging system manufacturer websites continue to be rich information-gathering sources. Conclusively, the research targets to develop theoretically yet empirically informed issues related to drone charging and flight duration, the alternative solutions to manually replace drone batteries and addressed the most effective solution to the stated problem, i.e., wireless charging of drones. (Organizing Your Social Sciences Research Paper: Qualitative Methods, 2018)

Chapter 4: Findings

The drone technology is one of the emerging technology of today's world. Initially, the drone industry was limited to military use, but now the technology is being commercialized. Aquila drone, which belongs to Facebook, flies for three months at a height of 50 km above sea level by using solar cells. Korean Institute of Materials flies a hydrogen fuel cell drone for one hour. The hybrid drones that are commercially used are still in their initial stages; there is a risk of explosion if operated through hydrogen fuel cells and are not safe for commercialization. The drones that utilize solar technology for their elongated flight have limited mission space, location and weather conditions; hence not suitable for various missions.

The UAVs are used to take orthographic photos by surveying the objects and grounds to produce point clouds, 3D models, volume calculations, and height. Solar parks, power lines, engines, and parks are being inspected by drones. They are also being used for bridge inspections, including visual structure examination and monitoring. Drones are used to inspect oil, gas and power plants. The aerial images and photos are generated by the UAVs. They are used in advertising, product and state photography. The drone technology is capable of conducting landscape photography to 360-degree spherical panoramas. They are also used for point-of-interest and circle-of-interest imaging. The applications of drone technology also include aerial movies and videography. Moreover, drones are used to conduct condition analysis and target analysis to document construction areas. They are used for structural and wall monitoring and plant and wildlife monitoring. (UAV Applications, 2018)

Drones are being used in almost every field of life where inspection and surveys are required. Much critical information is gathered through drones. But there are some limitations with drone technology and the major issue is limited flight duration. To work effectively and efficiently, the drone should be able to take a long flight and try to get every aspect of information regarding their mission. Many inspection and survey companies use hydrogen fuel cell and solar cell technology to charge UAV batteries, but there are many drawbacks. Hence, the most effective solution to maximize the flight duration is the utilization of wireless charging systems.

Before focusing on wireless charging solutions for drone technology, let's analyze some other alternate solutions to extend the flight time of a drone. The drone battery life can be extended by

reducing the weight of the drone. With less weight, motors had less to lift and required minimum power to wind up. In this way, done can be in the air for a longer time. The user can remove the extras of the drone, such as prop guards and camera, if not required. In this case, the drone cannot be used for inspection or survey purposes.

The battery begins to lose its power as soon as it is removed from the charger. To get the maximum advantage of battery, try to use it as soon as you remove it from the charger if possible. Lithium polymer batteries can be destroyed if they are used until they are drained completely. Most drones land or finish up their flight before the battery is completely drained off. However, if there is no such functionality in the drone, then do not fly the drone until the battery is completely exhausted. Try to get new extra batteries, as old batteries hold less charge and hence lower the flight time of the drone. (Bagulay, 2017)

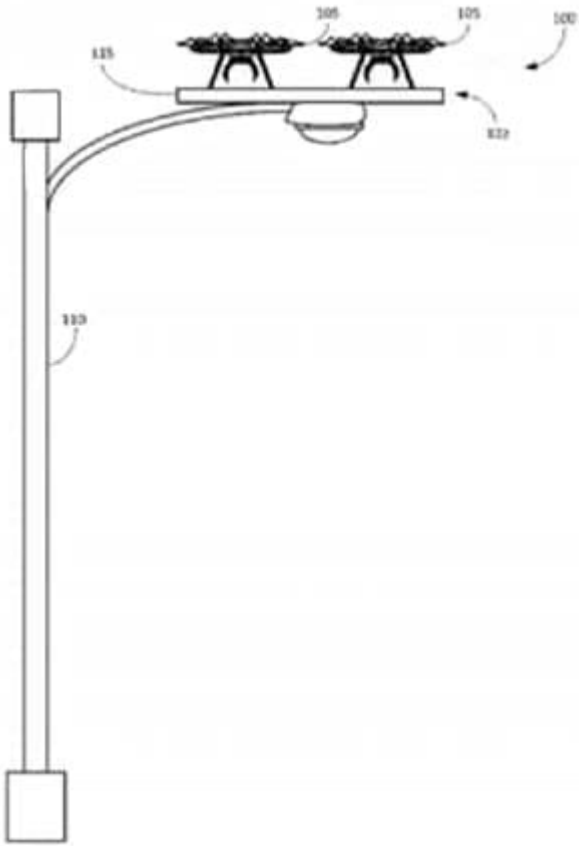
Tethering a drone is another solution to extend the drone flight. The tethering system provides power to the drone through a long cable. The drone can fly as long as there is a power source on the ground. Connect one end of the cable to the drone charging unit and the other end to the tethering system, which is further connected to the wall socket to get constant charging. Through a tethering system, one can fly a drone indefinitely, but as the flying range is limited because of the length of the cable, the drone can be used for limited purposes like aerial time-lapse or security. (Bagulay, 2017)

Wireless Charging Systems:

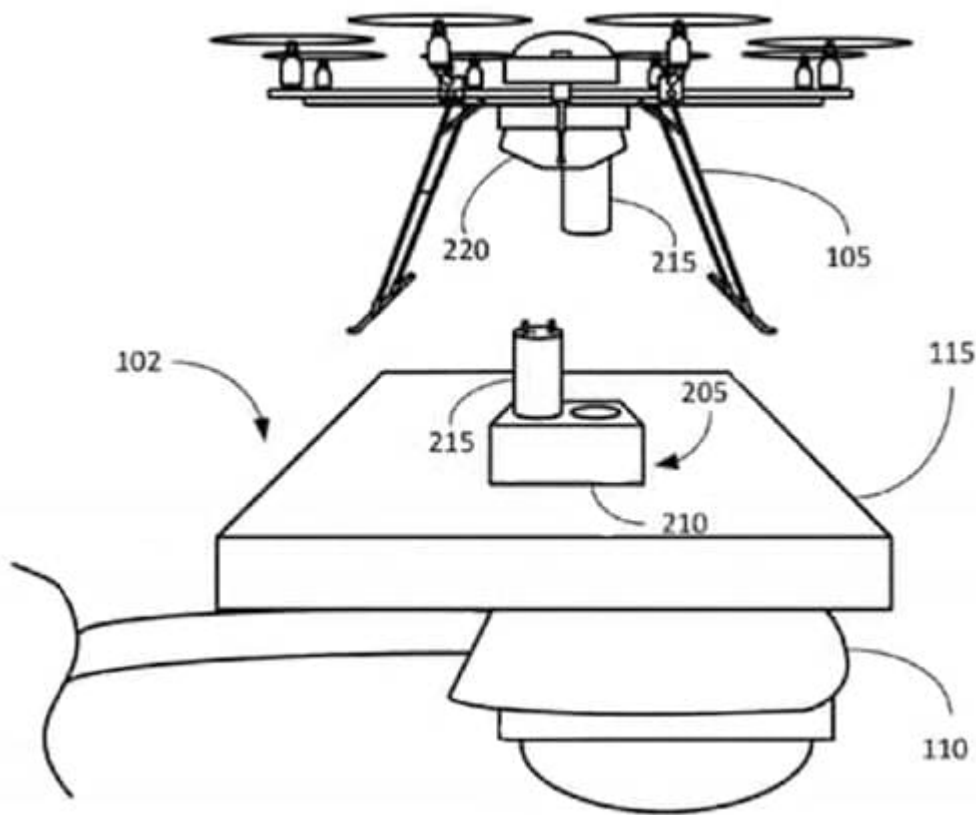
One of the greatest achievements in ramble innovation is the capacity for automatons to wirelessly charge using a wireless charging station. Organizations are striving to build up the wireless charging innovation, which could alter the drone world. Envision not regularly landing your drone to charge it? Simply float it over a wireless charging station and enable it to revive while drifting. Other than the additional advantage of longer flight time, a wireless charging station would dispose of the need to purchase additional batteries for your automaton or need to manage to connect it. (Drone Charging Stations: What's the Best Way to Charge Your Drone? 2017)

Drone Docking – Park Assist

Air conveyance drones have drummed up a significant buzz without entering the administration. As of late, the firm distributed a proposition for introducing docking stations on road lampposts, giving knowledge into the sort of calculated difficulties its advancement groups are handling. As a place for exchanging loads, these stations can give adaptability to conveyance arranging and, maybe more vitally, a charging point for the vehicles to re-stimulate before proceeding to the last goal, sitting tight for the next task, or coming back to base. The lamppost is likewise, advantageously, associated with an electrical supply. (Editors, 2016)



To energize, an independent vehicle must interface precisely with the charging anodes given on the docking station. The arrangement of the docking station and the drone is the following:



To position the vehicle before docking, various choices might be practical. Existing robot-docking frameworks give a couple of cases to consider.

Robotic vacuum cleaners, similar to the Roomba, have been in the market for quite a while and handle battery charging independently by checking the battery condition amid cleaning with a specific end goal to decide when to come back to the base station to revive. The base station produces an infrared reference point, and the Roomba locks onto this flag keeping the guide in the focal point of its field of view as it returns.

The open-source ardu mower robotic lawnmower venture utilizes a marginally extraordinary system. At the point when the battery voltage falls beneath a level demonstrating charging is fundamental, the vehicle will take after a border wire installed in the ground to come back to its charging station. By following the wire precisely, the cutter lands at the passage to the docking station in an appropriate position to be guided towards anodes inside the dock that reach charging pads on the vehicle surface.

Visual arrangement is another choice that has been exhibited in different activities. The creator group is a hive of robotic experimentation, including this online video demonstrating how a front-mounted camera is utilized to find a charging station and guarantee rectify arrangement. The robot in this show, which utilizes Raspberry Pi and Arduino PCs, stops a few times to modify the arrangement and can remedy its position by a couple of centimeters each time. Calibrating the vehicle's position may show a more mind-boggling challenge when the vehicle is an airborne automaton drifting over the

docking station.

China has handled the difficulties in independently adjusting the modules of a reconfigurable robot framework utilizing a blend of visual pre-arrangement and consequent high-precision arrangement utilizing direct Hall sensors. This robot, called UBot, can reconfigure itself by improving modules as important to perform different errands, and is additionally equipped for self-repair by supplanting imperfect modules when required. A sensor module containing the CCD vision sensor and four direct Hall sensors in positions that compare to the areas of magnets in the dynamic docking module. The modules can move advance and sideways and can turn. The CCD sensor is utilized for target obtaining and to control the pre-arrangement stage. The signs from the direct Hall sensors are then used to control exact situating before mechanical mating utilizing a snare instrument finishes the docking methodology.

The visual arrangement is expert by removing perceived highlights from the CCD picture, figuring rakish and straight balances, and making direct alterations until these are inside 3 degrees and 4 mm individually. The dynamic module at that point draws nearer until the caught picture involves 80% of the field of view. The visual arrangement at that point ends, and the exactness arrangement utilizing the direct Hall sensors initiates. X, Y and precise revisions are ascertained from the yield voltages of the four Hall sensors, in connection to organizes on the module mating surfaces, to position the modules with exactness more noteworthy than 1 mm in both straight tomahawks and 2 degrees of rakish dislodging.

Remote charging is an option and is included in drone landing cushions right now promoted by different air solutions providers. Remote charging is, as of now, accessible for cell phones and electric vehicles. Charging can continue if the transmitter and recipient are isolated by up to a couple of centimeters. Nearer situating for quicker vitality exchange can be accomplished by managing the gadget to an ideal position or utilizing one of a few methodologies that enable the power collector to be situated uninhibitedly. These incorporate building various loops into the charging pad to produce an attractive field just in the region of the beneficiary or mechanically driving the transmitter curl to a position near the recipient.

A transmitter circuit is implanted in a drone arrival pad or automated docking station that interfaces with a coil whose shape, size, and weight can be adjustable for particular applications. After drawing closer, a drone's essence is recognized by the framework. A beneficiary coil mounted on (or installed in) the drone at that point starts to get control. One of the benefits of the new and upcoming drone docking station is the software that can "adaptively tune" the reverberation of the transmit and recipient coils, advancing their recurrence to represent changing separations and introductions in the middle.

On the off chance that the drone doesn't make an exact arrival on the pad, it can, in any case, set up a solid association with the power source. Software checking the relative position of the coil can give criticism to help enhance the accuracy of self-ruling arrivals. Coils are tuned for ideal charging,

notwithstanding when the drone and base station are defectively adjusted. Coils likewise give battery insight and administration, which is helpful to organizations sending bigger armadas. At the point when a drone's work is finished for the day, the unmanned artworks can gradually renew their batteries, which is ideal for battery lifespan. (Startups Leading The Way In Wireless Drone Charging, 2017)

Wi biotic Power pad:

Drones are awesome until the point that you understand running each one of those propellers, a camera, GPS and other grouped innovation bits is a genuine depletion on the battery. In case you're simply utilizing one for pictures, it's not very enormous of an arrangement. However, if you're utilizing one for looking over, security or conveying burritos, swapping out batteries all the time can be a gigantic torment and time-consuming. Luckily, there's another remote charging landing cushion on its way. (Baldwin, 2017)

The WiBotic PowerPad is a three-foot by three-foot landing station that accompanies an installed charger that can be appended to practically any automaton as indicated by the organization. The organization says the safe climate stage can be mounted essentially anyplace and can lighten the need to deal with drones that run robotized flights all the time.

The PowerPad additionally can fill in as a waypoint for long-separate flights. On the off chance that an automaton needs to study a substantial plot of land, it can stop and energize at consistent intervals on circulated stages. No word on evaluating or when the cushion will be accessible. However, there are certain to be more than a couple of organizations keen on lessening the time they spend swapping batteries while gathering information about battery wellbeing in the drones they have conveyed.

Atlas Nest:

The Atlas NEST is a landing, protective charging station that allows for BVLOS operation, extended flight range and constant drone readiness in remote locations. When the Atlas Pro requires new batteries to extend its flight time for missions in remote locations, it can autonomously land in a NEST charging station where a robotic arm changes the drone's batteries, allowing the Atlas Pro to continue flying to mission completion.

"NEST is not simply a docking station. It is a strategic component of our company's vision for fully autonomous drone missions," explained Guy Cherni, CMO of Atlas Dynamics. "The ultimate goal of the NEST, combined with our autonomous mission OS, is to make a highly sophisticated technology an accessible tool for professionals in every industry. Of course, the automation NEST provides a key factor in achieving this accessibility." (Atlas Dynamics releases drone charging station for longer flights, 2017)

The Atlas NEST, which can be stationary or motorized, is a part of the total drone platform solution the company is delivering to the professional market. Designed to enable constant drone readiness and a short time to target.

The Drone box:

The Dronebox by H3 Dynamics is a charging station right now accessible for drones. The Dronebox supplies a mechanized reviving and capacity station for drones that can be left unattended for a considerable length of time a period. Other than charging the drone, the Dronebox additionally stores the drone, opening when required and raising the stage inside so the drone can go without much of a stretch take-off. The drone would then be able to fly around, entire its assignments, and afterward naturally arrive back over the case. Once back inside, the drone is revived and prepared for its next flight. All data the drone may have obtained while in flight can be transmitted back to a local administrator. The Dronebox genuinely is progressive, not just because it would wireless be able to charge the drone, but also because it gives a home base to the gadget. (Drone Charging Stations: What's the Best Way to Charge Your Drone? 2017)

Humavox ETERNA Platform:

Humavox is changing the way we consider remote power with its ETERNA stage. It is very ideal, and compelling charging innovation ought to be sufficiently versatile so it can wear numerous shapes and structures. The ETERNA stage was intended to be an adaptable equipment stage, implying that anything from a bowl, knapsack, or cabinet can be changed into a remote charging station. For drones, this is particularly applicable. For instance, with Humavox's ETERNA stage, drones utilized for pursuit and save or law requirements could, without much of a stretch, be charged in a cabinet appended to a fire truck. Drones would effortlessly be revived in the middle of flights, making them more powerful and solid! Simply haul out the cabinet of the fire truck, drop the drone, and let it charge!

Chapter 5: Summary and Discussion

An unmanned Aerial Vehicle is an aircraft without any pilot. UAVs are controlled by the remote system. They can also fly as they are programmed. Drone technology is one of the emerging technologies of the recent era. They are being used for inspection and surveying fields, construction sites, bridges, etc. They are being used for taking aerial images and videography. Initially, they are used by the military only to carry out sensitive and remote operations. Now, they are being commercialized. The drone is divided into fixed-wing, quadcopter, and hybrid drones. The main drawback of drones is low flight duration. They stay in the air for just 25 to 30 minutes. The main objective of this research paper is to investigate the alternate solutions to extend the flight time of the drone.

The method of investigation adopted is qualitative and conceptual. The data related to our research has been collected through documents and text taken from media, journals, websites, drone manufacturer brochures and newspapers.

The drone can be used effectively to carry out different operations if it can stay in the air for a long time. Many companies have successfully flown their drones up in the air for a few hours to months by using solar and hydrogen fuel cells, which have many drawbacks and cannot be used commercially. To extend the flight time of drones, there are many solutions like minimizing the weight of the drone and tethering the drone. All these solutions have limitations, such as limited flight range. The most effective solution is the wireless charging of drones which is accomplished by manufacturing drone docking pads by WI biotic sky sense, atlas, and humavox air solutions. The drone senses the nearest wireless charging station, lands on it, is charged wirelessly and flies up into the air again.

Conclusion:

The drone technology is being used for military, surveying and inspection purposes. The drones are also being used for fun activities. The drone is capable of conducting many critical and important missions. The major loophole in drone technology is its minimum flight duration. Many alternative solutions have been analyzed, but the most effective and efficient solution is are Drone's wireless charging. Drone charging pads, platforms, and drone boxes have been manufactured by many air solutions providers. Drones, since the charging pads land on where it is wirelessly charged and resume flying to continue its mission.

Drones are a standout amongst the most intense types of innovation accessible today as a result of their different uses and applications from sparing lives to conveying productivity to an unheard-of level. In any case, with the end goal for drones to satisfy their maximum capacity and not depend on human mediation, a more viable charging arrangement is required. Envision a drone taking off without anyone else, traveling to your home and conveying a bundle, at that point coming back to its base to land and charge itself back to full power. That is the future of wireless charging!

References

- Atlas Dynamics releases drone charging station for longer flights.* (2017, September 17). Retrieved from UAS Magazine Website:
<https://www.uasmagazine.com/articles/1744/atlas-dynamics-releases-drone-charging-station-for-longer-flights>
- Baguley, R. (2017, January 20). *How to Extend the Flight Time of Your Drone.* Retrieved from TomsGuide Website:
<https://www.tomsguide.com/us/pictures-story/1016-improve-drone-battery-life.html#s9>

Baldwin, R. (2017, October 20). *Wireless charging will make drones always ready to fly*. Retrieved from Engadget Website:

<https://www.engadget.com/2017/10/20/wireless-charging-will-make-drones-always-ready-to-fly/>

Drone Charging Stations: What's the Best Way to Charge Your Drone? (n.d.). Retrieved February 9, 2017, from

<https://www.humavox.com/blog/drone-charging-stations-whats-the-best-way-to-charge-your-drone/>

Editors, E. (2016, November 22). *Drone Docking with "Park Assist" for Recharging in The Field*. Retrieved from Digikey website:

<https://www.digikey.be/en/articles/techzone/2016/nov/drone-docking-park-assist-recharging-in-the-field>

Qualitative Research Methods & Methodology. (2018). Retrieved from at last.ti website:

<https://atlasti.com/qualitative-research-methods/>

Startups Leading The Way In Wireless Drone Charging. (2017, June 7). Retrieved from Wireless Design mag Website:

<https://www.wirelessdesignmag.com/blog/2017/07/startups-leading-way-wireless-drone-charging>

THE 3 MAIN CATEGORIES OF DRONES AND THEIR ADVANTAGES & DISADVANTAGES. (2017, October 9). Retrieved from bot link website:

<https://www.botlink.com/blog/the-3-main-categories-of-drones-and-what-they-do>

UAV Applications. (2018). Retrieved from ascending technologies:

<https://www.asctec.de/en/uav-uas-drone-applications/>

Unmanned Aerial Vehicles. (2018). Retrieved from RAND Corporation Website:

<https://www.rand.org/topics/unmanned-aerial-vehicles.html>