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Potential Policy Issues with Flying Car Technology

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Abstract

Flying-car concept is a desirable concept to ease traffic congestion that exists in various parts of the globe. While flying cars has various advantages including reduced cost of building and maintaining traditional roadways, reduced reliance on road infrastructures, increased reliability of travel times, and reduced congestion, potential challenges with this technology can make it undesirable, if adequate planning, and technological implementations to ensure safety of people both on land and in the air, is not ensured. This report evaluates some potential advantages and challenges with flying-car technology, and proposed ways to address these challenges. Before flying-car technology is approved on a large scale, among other things, this report discussed the need to ensure appropriate tracking systems for flying cars, the need to ensure adequate law enforcement systems to control misuse of the technology, the need for technological innovations to minimize the impact of any mechanical faults or accidents on both the occupants of the flying-car, and people on the ground, and the need to ensure mandatory collision avoidance technology systems for flying cars. It is hoped that this report will generate more interest in researching ways by which this technology can be harnessed in a beneficial way for humanity.

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Keywords: Flying Car Technologies; Air transportation; Transportation safety; Congestion management; Transportation Policy

1. Introduction

Flying car technology is a desirable technology with enviable potential features when compared with the traditional vehicles on the road. Road traffic congestion has been of concern for humanity for a while, and this is expected to continue. Various traffic control devices (including traffic signals, stop signs, etc.) are used to ensure smooth and orderly flow of traffic. Kotwal, Lee, & Kim (2013) noted that since early twentieth century, traffic signal systems have been used to manage continuous flow of traffic and saturation at intersections, and also to help ensure safe and smooth automobile transportation. Traffic signals, when adequately timed, can be very efficient in allocation of right of way, or green times for traffic from various corners of the intersection. However, because of high demand for limited road space, especially at rush hours, a major road in a signalized area does not always have green time, resulting in delays at the intersection. Although traffic signals help to ensure smooth and orderly movement of vehicles, the presence of traffic signals also makes it possible for vehicles that depart from various destinations, at various times to be held up in a single platoon of vehicles on a road segment while waiting for their portion of green time, resulting in delay. Delay

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associated with road traffic congestion is sometimes quantified in monetary terms. Traffic congestion cost motorists in the United Kingdom more than £30 billion in 2016 (INRIX). A study by the Center for Economics and Business Research (CEBR) and INRIX into future economic costs of congestion in the United Kingdom, Germany, US, and France was used to estimate the cumulative gridlock cost for US and Europe. The cost of congestion for the economies was forecasted to be $ 4.4 trillion between 2013, and 2030 (CEBR, 2013). These costs of road traffic congestion make innovative ways to reduce congestion on the roads a great idea.

Flying car technology (a technology that allow 'cars' to fly) is one of the ways by which dependency on traditional roadways can be reduced. This technology offers the prospect to ease traffic congestion on the road. Flying cars brings the opportunity to be in the air like a bird, from various origins to destinations. This is expected to result in shorter trips, not only because there will be no need for signalized intersections, but also because people will be able to connect origins to destinations as the crow flies. Recent advancement in technology has also eliminated the need for traditional runways that are needed to fly at the airports. Karthik (2014) described a design which allows a motor to first fly upwards, then frontwards, rightwards, leftwards, etc. Bhivgade (2016) focused on developing an estimation method for a flying hover car which can travel both on the road, and in the air without wings and propellers. Vertical take-off and landing (VTOL) is a desirable feature for flying cars. Prototype of the VTOL system has also been demonstrated by various flying car manufacturers. Although flying car concept has desirable features, and has been around for a while now, it has not been able to make it to the market on a large scale. Although commendable efforts have been seen in the flying car industry, numerous challenges exist that may hinder successful implementation of flying car technologies, and there is a great need to review various issues that may arise with this technology. Of great concern is the safety of people in the 'flying car era'. To achieve great benefits from flying car technology, various pertinent questions as regards safety, security, and privacy of people needs to be addressed. Adequate policies, and efficient enforcement systems also needs to be put in place before commercialization of flying car systems in large quantities.

Traditionally, the word 'car' is used to refer to some forms of conveying medium. Various definitions for car include: a moving compartment (e.g. railroad car, trolley, or cable car); a road vehicle that typically has four wheels, powered by an internal combustion engine, and can carry a small number of people; a railway carriage; a passenger compartment of a cableway, lift, etc. (online dictionaries). If any of these conveying mediums are designed to have a technology that allow the moving compartment to fly, it will be called a flying car in an urban air mobility (UAM) system. Thipphavong et al (2018) defined urban air mobility (UAM) as a safe and efficient air traffic operations for manned and unmanned aircraft systems in a metropolitan environment. Kohlman & Patterson (2018) described urban air mobility as an emerging transportation concept that includes the movement of cargo and people in vehicles that fly at low altitudes over metropolitan areas. Thipphavong et al noted that types of operations for urban air mobility vehicles could include package delivery, weather monitoring, passenger transport, humanitarian missions, news gathering, rescue operations, ground traffic flow assessment, and emergency medical evacuations. It is no doubt that the physical and technological designs / requirements of the conveying medium for some of these operations will be different. Flying cars exist in various forms / design. Kohlman & Patterson (2018) referred to the helicopter operations of Blade in New York as one of the limited forms of UAM that occurs today, and noted that the media often refers to UAM vehicles as "flying cars". When addressing the issues about flying car systems and the related transportation safety issue, there is need to ensure a comprehensive review that is not only limited to helicopters. The review should include potential issues with all forms of cars that fly, including road vehicles that are made to have technologies that can take them to the air. This report attempts to address some of the potential policy issues and questions with the flying car system. Most especially, the study focuses mainly on evaluation of some of the major potential policy issues that requires adequate attention before large scale approval of vehicles that can be operated both as a roadway vehicle and also as a flying car.

Given the additional privilege that flying cars will have over traditional automobiles, and the ability of these cars to fly to a reasonable distance close to people's place of abode, potential policy issues that were discussed includes: the need to ensure appropriate tracking systems for flying cars, the need for technological innovations to minimize the impact of mechanical faults or accidents from flying cars, the need to ensure mandatory collision avoidance systems for flying car technology, the need to ensure strict maintenance requirement and periodic air worthiness test for flying cars, the need for adequate law enforcement systems to control misuse of the technology, the need for establishment of no-fly-zones, flight paths and manuals, the need to establish appropriate search and rescue operations and alarm systems, the need for establishment of sustainable finance systems for the technology, the need for environmental impact study in various municipalities, etc. It is recommended that these critical issues be given adequate consideration in every community. If a community does not have adequate infrastructure and technology to ensure safety of people both on the ground and in the air, in the flying car era, the flying car system is not recommended for such a community.

Some examples of flying cars, and aircraft in the present day includes:

- AeroMobil (https://www.aeromobil.com/flying-car/)
- Fancraft™ by Urban aeronautics. (http://www.urbanaero.com/)
- Lilium (https://lilium.com/)
- Pal-V (https://www.pal-v.com/en/about-us)
- Terrafugia TF-X (https://www.terrafugia.com/tf-x/)
- Volocopter (https://www.volocopter.com/de/product/), etc.

2. The need to ensure appropriate tracking systems for flying cars

Flying cars brings along additional privileges that does not come with traditional automobiles. With a flying car, it is possible to easily bypass some traditional security features. Fences to various properties will not be a very useful security feature when there are flying cars with vertical take-off and landing capabilities. This brings about the need to have adequate tracking system that can identify the location of all flying cars. If there is no good tracking system, if a crime was committed using a flying car, with vertical take-off and landing system, recognizing which car was used to perpetrate a crime may be difficult. This may be a big issue for law enforcement officers in crime investigation. Privacy of people within their properties could be reduced if people fly close enough to the property. As a result, there is need for more accountability with the ownership of flying car. Anyone that wants a flying car should also be committed to respecting the privacy of others. Recognizing the added privileges that flying cars have, it is necessary to ensure that tracking systems exist which is able to detect which car has flown in any particular area of a municipality.

There has been advancement in tracking technology systems Satsangi, Whiteson, Oliehoek, & Bouma (2017) noted that automated tracking is crucial to a lot of computer vision applications. Ramani et al (2013) in their study about vehicle tracking and locking system using GSM and GPS discussed a low-cost system in which the place of a vehicle can be tracked using Global System Mobile Communications (GSM) and Global Positioning System (GPS). With this system, if needed, an authorized person can send an SMS to a micro controller which has the capacity to stop the engine. In the effort to overcome the pertinent road traffic congestion challenges through flying car technology system, there needs to be a good cooperation between law enforcement officers, and the manufacturers for the flying cars. In addition to ensuring that law enforcement officers have adequate system that can track the movement of any flying system, law enforcement officers should also have the capacity to remotely stop a flying car, and bring it to safe landing. This system needs to be adequately worked out between the car manufacturers and the law enforcement before consideration of large-scale approval for flying car systems. If flying cars are allowed without adequate tracking and control systems, there will be more concern about security of people in different places. Even border control agents may have a lot of trouble in trying to monitor the kind of goods that come in to a country from various sources. After the concern about tracking, and the ability to stop the engine of a flying car must have been addressed, the next potential policy issue is about how to bring the flying car down to safe landing by law enforcement officers without being a hazard to other road users, people, or properties on land. A policy question that will need to be answered as regards ensuring appropriate tracking systems for flying cars is whether it will be good to allow commercialization of flying cars in large quantities without adequate tracking systems, given the potential issues discussed in this section.

3. The need for technological innovations to minimize the impact of mechanical faults or accidents

There is a need to establish appropriate policies to minimize the potential impact of accidents on both occupants of flying cars and people on the ground. In any occasion when law enforcement officers need to remotely stop the engine of a flying car, this needs to be done in a way that there will not be fear of the car dropping on people, or on various properties with a high impact energy. This calls for more research on how to minimize the impact of flying cars on people. The heavier the weight of an object, the more dangerous the impact will be if it drops on people or on the roof of a building. In a similar way, the higher the speed of a heavy object, the more dangerous the impact will be on people or property. Using the principle of potential gravitational energy, with the assumption that the acceleration due to gravity is constant at $9.81 m/s^2$ for the given heights, figure 1 below shows the expected gravitational potential energy for objects with varying mass that drops from various heights. From basic principles of physics, it is known that gravitational potential energy is a function of mass of an object m, acceleration due to gravity g, and height of the object, h. i.e. $Gravitational\ potential\ energy\ =\ mass\ x\ gravity\ x\ height$ (RM Plc, 2006). The kinetic energy (before impact), for an object that is dropping from a height is also equal to its initial potential energy. This is with an assumption that the height of drop when compared to the radius of the earth is small, and the air friction is negligible (i.e. when an object falls from rest, the gravitational potential energy is converted to kinetic energy - HyperPhysics).

In addition to the weight of a falling object, the height from which the object falls is also a factor that can have effect on the resulting impact energy from the falling object. Hence, one of the major policy issues with flying car technology is how to minimize the potential impact energy of the flying car on objects on the ground. While it is desirable to minimize the weight of the flying cars, there is also a need to ensure that the weight is adequate for safe travel in turbulent wind. It is known that some hard materials will break when they drop from a height. A good goal to achieve a safer design for air transportation systems that will be in a better position to protect the occupants during crash landing situations will pay attention to the factors that affects the ability of the transportation medium to withstand a crash landing (if it occurs). This report recommends that the expected energy with which the flying aircraft may hit the ground during a crash-landing be given adequate consideration in the design of materials for all flying aircrafts. The goal is to achieve an air-transportation system that can provide a better protection for the occupants.

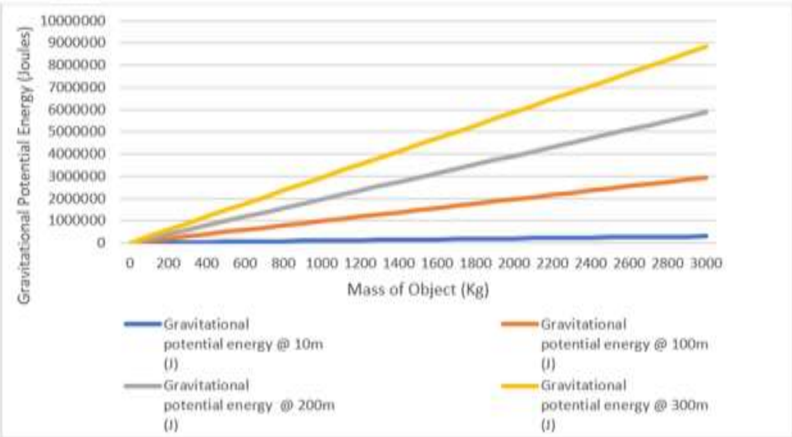

Fig. 1. Gravitational potential energy of objects falling from varied heights.

3.1. *How may the energy of impact of an object be reduced before reaching the floor?*

The parachute technology has been used to control the movement of an object, or person from the air. Powered parachute has also been used in flying and landing operations. The parachute technology helps in ensuring that the speed by which an object reaches the ground is reduced to a safe speed to avoid crash landing. The same technology can be made mandatory for the flying car industry to ensure that cars in the air do not drop on objects on the ground with a high impact energy. While it is not desirable for flying cars to fall from the air, in future, it will also not be desirable for any part of the flying car to fall from the air. Hence, if any flying car has some detachable components, before airworthiness testing, a good technological recommendation for manufacturers of UAM vehicles will be that all such detachable components in any flying car be equipped with efficient and reliable technological systems that can reduce the speed by which such an object may drop in-case a mechanical fault occur while in the air. Thipphavong et al mentioned a previous situation in which parts of a broken helicopter blade fell to the ground from the helipad on a roof, killed a pedestrian and injured another. Witkin (1979) mentioned about a helicopter (carrying 15 passengers, a flight attendant and divo pilots) that began to shake severely shortly after take-off. Even though the crew were trying to get back to the runway for an emergency landing, being out of control, the helicopter dropped from an altitude of 100 feet. The preliminary evidenced indicated that the emergency occurred when one of the five tail rotor blades snapped off, apparently, as a result of metal fatigue. It will not be desirable to see a recurrence of such accident in any place. Rather, it will be good to incorporate lesson learnt from previous crashes to improve future designs.

From figure 1 above, it is obvious that the gravitational potential energy increases with both height of object, as well as the weight of the object. The parachute technology helps to retard the effect of acceleration due to gravity. When answering frequently asked questions about powered parachute, and powered paraglider, Inland Paraflite Inc. noted that the maximum weight that can be carried depends on the strength and size of the canopy as well as the strength of the frame for the powered parachute. This report recommends that more research be done on how powered parachute technology can be improved to ensure that all flying transportation systems (flying cars, airplanes, helicopters, etc.) can be equipped with a system that can help reduce the effect of acceleration due to gravity to prevent crash landing. Before approval of large-scale production of flying cars, it is recommended that any manufacturer that wants to be a part of the flying car production companies ensure that all the cars produced have reliable technologies in place that can prevent crash landing.

Some risks still exist even if flying cars can land without crash-landing. Hence there needs to be adequate systems in place to ensure that some autonomous systems exist which will automatically prevent landing on undesirable objects. For example, all flying cars should be equipped with adequate sensors that will be able to detect, and prevent landing in a situation where there is not enough space for landing, prevent landing when there is a potential hazard on the parking spot; such systems should be capable of prevention of landing on people, or roofs of buildings. Note that at least one of the flying car manufacturers mentioned in the introductory section of this report already claims to have ballistic parachutes for the whole vehicle. At least one aircraft also claims to have autonomous capabilities. To ensure that flying cars do not fall on people, it will be desirable to see that such system are automatically deployed if an unusual maneuver is detected. For example, if a driver suddenly develops a medical condition, and is not able to deploy the ballistic parachute system for the entire vehicle, such automatic deployment of the ballistic parachute should take over the control of the flying car system. If situation arise in which a law enforcement officer had to remotely stop the engine of a flying car for security reason, at such instance, it will be desirable to see automatic deployment of adequate parachute system, or any other technology that can bring the vehicle down to safe landing. All these systems need to be adequately tested to ensure reliability before approval of mass production of flying cars by any manufacturer. More research on how video, GPS, sensor systems, parachute technology, or other advanced technologies can be applied to ensure safe landing of all flying cars without harming people or damaging properties is recommended.

One of the issues that sometimes comes up when airplanes crash land is fire outbreak. Certainly, it will not be desirable to see this with flying cars. Hence there is need for more research in this area too. For any air transportation systems that is powered by fossil fuel, potential areas for improvement in research is how to ensure that:

- The material for the fuel tank is made of durable components that is able to withstand high impact force without breaking apart
- Reliable flow stopper exist that will automatically shut-off flow of fuel from the fuel tank to the engines, when there is an engine failure, or there is a high likelihood of crash landing.
- Essential parts of the air transport system that may be in contact with fuel are made with fire proof materials.
- Systems to start firefighting process are automatically enabled if a crash landing occurs.

It is recommended that more research be done to ensure that all air transportation systems are equipped with reliable systems (like the parachute technology system, or any other applicable advanced technology system) to prevent crash landing of the entire aircraft. Whether an aircraft is fossil powered or electric powered, adequate testing to predict the stress level that the occupants may be subjected to if there is a crash landing from various heights is also recommended.

Such test may include both computer simulations, as well as testing with actual aircraft from various manufacturers while robots that are equipped with stress testing systems are in the aircraft. The results from such stress impact tests should be used to improve on the manufacturing components of the air craft until a stage in which the likelihood of fatality during any mishap in air transportation is zero. In addition to the above research recommendations for the air transportation systems, if the engine of a flying car shots off while flying on a large body of water, it will also be desirable to see that flying cars have systems that will ensure adequate floatation and safety of the occupants of the car in water until search and rescue team arrives. Given the issues discussed in this section, the policy efforts here will be to evaluate the technological readiness of the flying car systems to see if they have adequate safety features to prevent a recurrence of mishaps that have happened in air transportation in the past, and ensure safety of people both on the air, ground, and water.

3.2. Need to ensure mandatory collision avoidance systems for flying car technology

Using information gathered from 180 countries, the World Health Organization stated that the number of fatalities on the roads annually has plateaued at 1.25 million per year (WHO, 2015). Durić & Miladinov-Mikov (2008), noted that the road, vehicle, and human factors are responsible for traffic accidents; Meanwhile, human factors, either by itself, or in association with other factors, account for more than 90% of car accidents. Modern advancement in technology has brought humanity at large closer to a state by which autonomous controls can help to minimize the negative impacts that are caused by limitations from human factors in driving operations. While it is highly important for humanity at large to embrace improved technologies that will help reduce the number of road traffic crashes, and the resulting property damage, injury, fatalities, and other consequences, it is also very important that humanity at large do not make a mistake of accepting new transportation systems into the air, if this transportation system do not come with reliable, automatic collision avoidance systems.

At the present time, someone that is living in a third floor of a building may sleep at night without having to worry that a car may crash into the room at night, but if flying cars are allowed without reliable, and mandatory collision avoidance system that no driver can override, then even people living at the top floors in high rise buildings may still be at high risk of having flying cars crashing into their homes. Given that various reasons (including fatigue, absent mindedness, driving under the influence, etc.) may cause humans to lose control of the driving operations, (and not all these issues are detected by law enforcement officers before the accident occurs), it is therefore recommended that no flying car should be allowed in the air without having reliable autonomous collision avoidance system. If desired such systems may be made as semi-autonomous giving human-drivers opportunity to choose the direction of travel or landing spot. For flying cars, human drivers should never be given the opportunity to override the automatic braking system that is designed to prevent crashing the flying car into any object. It certainly will not be desirable to see cars crashing into each other in the air, or with people if the car is on, or close to the ground. It will not be good to see cars crashing into overhead power lines. It will also not be desirable to see terrorist use the cars for suicide missions. Hence, research into technological innovations that will alert the car manufacturers, as well as the law enforcement officers if anyone tries to tamper with the automatic collision avoidance systems of the flying cars is recommended.

While flying car system will be helpful in reducing congestion on the roadways, it is good to note that some congestion, and potential conflicts may still exist at some hot spots like some entrances to covered or underground parking lots, some specific take-off and landing areas, if regulations calls for that in certain municipalities. To reduce potential conflicts, and improve safety, it will be a good idea to see that flying cars come with connected vehicle technology, so that the vehicles may communicate with each other, and know when a certain parking / landing spot is already taken by a flying car that is already in the landing process.

3.2.1. Ensuring strict maintenance requirement and periodic air worthiness test

Given the need to ensure safety of people not only in the air but also on the ground, stringent maintenance requirement, periodic inspection and testing should be enforced for the flying cars to see if the cars are “air worthy” or not. If the cars do not pass a minimum standard for air worthiness, it should not be allowed to fly. Designing a car that fly is not the only breakthrough that should automatically bring the cars to the air, designing systems to ensure safety of people both in the air, and on the ground, should be a complete package for the technology.

Advisory circular AC 21-42 (2014), of Australian Government's Civil Aviation Safety Authority (CASA) on the requirement for light sport air craft (LSA) manufacturers noted that, for as long as the LSA is registered in Australia, the manufacturer is required to monitor and correct flight safety issues. The owner, or registered operator of the aircraft is also responsible to report any difficulty during the service life of the aircraft. Such system that assigns some responsibility to both the manufacturer, and the registered user is desirable for safety systems in the flying car era.

4. The need to ensure adequate law enforcement systems to control misuse of the technology

Law enforcement officers in any country are needed to maintain law and order. Without having flying cars in the air, law enforcement officers already have various challenges. How will it look like if someone that is being chased by law enforcement can just switch to Vertical Take-off and Landing (VTOL) mode, without the law enforcement officers having adequate technology to automatically override such system in any car? Noting that this may make law enforcement a little more difficult for the police, during the planning operations for the flying car technology, it is recommended that all the intending flying car manufacturers work with the local law enforcement officers, and the international police agencies to ensure that the law enforcement officers from any country have the capacity to be able to both override the VTOL mode of any flying car, (i.e. prevent the car from flying) and also safely bring the car to the ground, if it is already in the air. A policy decision in this regard in various municipalities will be to answer the question, "if our law enforcement officers do not have the technology to prevent a vehicle from switching to flying mode, will it be reasonable to say that our law enforcement officers are ready to ensure a good enforcement of law and order in flying car era?"

4.1. Border Security

When it comes to the issue of border security with flying cars, concerns that may exist includes people having opportunity to fly across international borders without having to be checked by law enforcement officers to know which goods are crossing the borders. An annual report questionnaire for 2015, by the United Nations Commissions on Narcotic Drugs appeared to relate money-laundering, financing of terrorism, trafficking in persons, etc. as part of criminal activities that may be associated with trafficking of psychotropic substances, and narcotic drugs. The international drug control conventions by the United Nations recognizes addiction to narcotic drugs as a serious evil for the individual that comes with social, and economic danger for humanity. The international drug control document also noted that effective measures to guard against the abuse of narcotic drugs requires coordinated and universal actions that warrants international cooperation that is guided by common objectives, and same principles. The concern about illegal trafficking of goods and services across international borders also creates a potential policy issue that requires adequate attention and planning before large scale approval of flying cars.

This issue may be addressed using a semi-autonomous system in which possible destination for the flying cars will be limited by a list of pre-programmed destinations. These pre-programmed destinations may be limited to places within the borders of the country. If this system is used, it may mean that possible destinations for flying cars will be localized to the destinations within the country where the flying car is licensed. If flying cars that are registered in a certain country are to be operational in another country, there may be a need for an international regulation to have mutually agreeable standards on this. These standards may include various tests to ensure that preprogrammed destinations of flying cars do not include any area of any country that may be designated as "no fly zones" for flying cars.

Research report 2017-R002 of Canada's department of public safety and emergency preparedness indicated that in 2015, 37,194 seizures of drugs that were listed in the Control Drugs and Substance Act (CDSA) were made by the Royal Canadian Mounted Police – RCMP (Mawani, Maslov, & Lawrence, 2017). One may wonder if that much drugs are originated from within the country, or if some of them cross the international borders to get into the country.

Various news is available online about drug seizure at border crossing. The US customs and border protection agency also have some more information on statistics of drug seizures. To limit the challenge of law enforcement officers that deals with the use of drugs in any country to drugs that are already in that country, and not increase the work load by trying to track drug dealers that may eventually be using flying cars across international borders, there is a need to give proper attention to adequate planning to ensure that possible destination for flying cars are not allowed to include ones that will promote transportation of illegal substances across international borders.

4.2. Establishment of no-fly zones, flight paths, regulations and manuals

For security, and safety reasons, except for special exceptions, there may be a need to create some 'no-fly' zones for flying cars. Places that may be designated as no-fly zones may include any place that may be seen as a security risk to any community if anyone is allowed to fly their cars in that area. In planning for flying cars, the law enforcement officers of any country may be helpful in creating a list of places that will be listed as no-fly zones. The citizens of a country may also have contributions to the list for 'no-fly zone' in their country. Having adequate pre-programmed possible destinations as semi-autonomous systems in flying cars, should help ensure that the flying car will refuse to switch to flying mode, if the input-destination includes places on the no-fly zone list. The law enforcement officers of any community should be obliged to inform the car manufacturers of any update to the no-fly zone list, and this may also necessitate periodic automatic updates of all flying cars from their manufacturers, as the no-fly zone list is updated in any community.

4.2.1. Airspace integration with tradition commercial aviation,

The issue about integration of the airspace with traditional commercial aviation is a serious issue for safety of air transportation both for the users of the traditional commercial aviation and for the prospective users of the UAM vehicles. Various measures including collision avoidance systems, establishment of new rules and regulations for all users of the airspace (both traditional commercial aviation and the new entrants in UAM) will need to be put in place to avoid potential conflicts in the air. A major policy question here will be, "if these regulations are not in place, will it be safe to legislate UAM on a large scale in any community"? Generally, when Visual Flight Rules (VFR) apply, flights must not fly lower than 100ft (300m) over congested areas of cities, of 500ft (150m) in other places. Although many manned aircraft systems such as police, fire and ambulance helicopters fly below the normal elevations for VFR rules, it is obvious that with the introduction of unmanned aircraft systems, (UAS) many of the UAS flights will also be flown below the limits. Many of the activities in which UAS are used can be performed by pilots who do not know about the rules of the air (Eurocontrol 2018), raising safety concerns for air transportation system. It has also been noted that certain organizations have come up with proposal to fly UAS at very high levels. With this in mind, a report by Eurocontrol proposed establishment of both Low-level flight rules (LFR) and High-level flight rules (HFR). The policy issue here may attempt to answer the question whether it is safe to allow vehicles flying at low altitudes in large numbers in various municipalities without establishment of adequate flight rules and guidelines for operators of these systems. An urban air mobility (UAM) market study (focusing on three potential markets: Airport Shuttle, air ambulance, and air taxi), presented to NASA in 2018 indicates that the UAM market faces both technological and non-technological challenges (Booz, Allen, & Hamilton 2018). Among other things in the non-technological constraint, there is concern about safety and security screening; in the long-term, passenger's understanding and trust with automation and pilot-less UAM may be an issue.

Establishment of flight paths, manuals and regulations should come alongside with the creation of no-fly zone list. Although with flying car technology, it is envisaged that trip distances and trip times will be reduced because cars can fly directly to various destinations in a straight line, if there exist a 'no-fly' zone along the path of the destination, in some instances, there may be a need for some change of direction, or change of travel mode before reaching the destination. This calls for the need to establish flight path, regulations, and manuals. Establishment of regulations and manuals for a car to be in flying mode may require a reasonable degree of collaboration between the department of transportation and the aviation authorities of any country. There may be a need for some international regulations on this too, to ensure that drivers from various countries are familiar with a common system to switch between air and land transportation. Although, with the VTOL technology, the airport is not needed to get a car into the flying mode, there is need to have adequate regulations in place to ensure that flying cars do not fly to the areas of town or heights where they will be a hazard to airplanes. In a situation where a flying car needs to switch from the flying mode to the driving mode, where traditional roads may be used, there also needs to be regulations which will be known to both the owners of flying cars, and the owners of traditional cars. If an unauthorized flying car accidentally goes beyond the limit for no-fly zones, it is recommended that reliable systems exist that will both notify the law enforcement unit of any country, slow the car down in the air, and automatically bring the car down to safe landing. In addition, it certainly will not be desirable to have cars flying beside people's windows, neither will it be good to see people using flying cars to intrude on the privacy of others.

Establishment of good flight paths may also help to minimize the risk of having cars making emergency landing, or crash landing on people's roof (if the flight paths are designed to avoid flying over people's place of residence). Before approval of flying cars (with new regulations), in a large scale in every community, there will be a need for re-training of crews in the aviation industry to be at the same page with new regulations. Hence, a comprehensive policy review will seek to confirm that all people that are working in the aviation industry are up-to-date on the new standards that is related to their work. Similar to driver training and testing in road transportation, it will be good to have adequate training, testing and certification procedures for operators of flying cars. To ensure that everyone that operates flying cars are aware of the flight rules, it is recommended that adequate regulations be instituted in every community to prevent operators that do not have appropriate certification from operating flying cars. This is hoped to ensure that those who are not aware of flight rules do not ignorantly constitute safety hazards for other people using air travel systems.

4.3. Addressing the issue about noise

Previous studies have raised the concern about noise from aircrafts (Vascik & Hansman, 2018). Basner et al (2017) defined noise as an unwanted sound that also includes noise from aircraft. Basner et al, also noted that the noise from aircraft is regarded as the most detrimental effect of aviation that can cause disrupt sleep, community annoyance, could increase the risk of cardiovascular disease of people living around airports, and can adversely affect academic performance of children. The International Civil Aviation Organization (ICAO) also noted that the most significant cause of adverse community reaction relating to operation and expansion of airports is aircraft noise, and the case is expected to remain the same for the foreseeable future, in most regions of the world. When dealing with the issue of noise from aircraft, in addition to the noise level, frequency of the flights in relation to the noise level, and the time of day the flights occur are potential issues to consider. It will not be a good thing to have aircraft noise disturbing the peace of people. For anyone who has difficulty in falling asleep, it may not be a pleasant thing for such a person to be awaken from sleep because of frequent noise from aircraft. US DOT, Federal Aviation Administration (FAA) noted that the noise from aircraft and airport are complex subject matters that has been studied for decades, and are still being studied today. FAA (2018) noted that aircraft noise is regulated through standards that are set internationally, and are applied when an aircraft is obtaining an airworthiness certification. Aircraft noise in UAM era may result in a big concern, if people who have had their houses in areas where it is not likely to expect noise from air craft begins to get such noise. Hence, the noise problem needs to be carefully addressed in the policy analysis approval processes for UAM vehicles.

The issue about noise can be addressed together with the issue of privacy. Privacy as relating to the proximity of the flying vehicles to residential houses, and the noise that can be generated during such proximity can be addressed by a careful establishment of flight routes and guidelines on proximity of the flying air crafts to residential communities. When on ground, the use of autonomous systems that can recognize the location of the vehicle in reference to proximity to residential neighborhoods and prevent transitioning of the vehicle to flight modes in areas where flying cars are not allowed may be researched and implemented. When in the air, the use of autonomous systems that can recognize the proximity of the vehicle to residential neighborhoods, slow the vehicle down, communicate the reason for the reduced speed, to the aircraft operator, and suggest alternative routes to avoid encroachment into areas that may be considered as infringement of privacy may be further researched and implemented.

Previous works have mentioned about vertiports (Daskilewicz et al (2018), Eastman (1971), Lindley (1968), Stein & Vicanek, (1992), German, Daskilewicz, Hamilton, & Warren (2018) etc.) A careful design of such infrastructure, in connection with adequate flight paths may be used to address the issue of noise and privacy. In this system, people who intend to take their cars to the air may have to drive from their residence to approved vertiports, before going into the air. The landing operations may also be limited to approved vertiports, (except for emergency landing, which may be duly investigated). A design that ensures a careful selection of flight routes with approved sites for take-off and landing operations may also help to minimize the probability that a flying car will fall on pedestrians or other motorists. If flying cars are made to drive away from residential neighborhoods (for a considerable distance) before going in the air, and if they are made to land at sites that are at a considerable distance away from residential neighborhoods, the concern about noise may be addressed to a good extent. Some of the operational challenges that was envisaged in a mismatch of UAM demand and availability of suitable ground infrastructure to support the operations includes increase in first and last mile requirements for ground transportation, resulting in increased expense, time, complexity to trips, airborne and surface congestion in proximity to take-off and landing areas (Vascik & Hansman, 2018).

If there is an airport in a certain location, there will be noise complaints from residents in the community (Spence, 2018). Spence further noted that to minimize the effect of noise on communities, some federal regulations have targeted noise production. Netjasov (2012) categorized eighteen noise reduction strategies under a balanced approach to four categories these includes: decreasing of noise at the source, land use management and planning, operational procedures for decreasing noise, and operational restrictions on air traffic. When planning for UAM, it will be a good thing to adequately consider potential impact of noise from vertiports if any vertiport is to be cited very close to residential communities. Although take-off and landing areas that are far from residential neighborhood may not be very attractive to an owner of a flying car, it is good to note that there will be need for some trade-offs in the effort to ensure that urban air mobility systems do not generate serious troubles. Lesson learnt from previous studies on noise reduction strategies for air transportation may be further explored for UAM systems.

Daskilewicz et al (2018), in defining Urban air mobility indicated that UAM is envisioned as low-cost transportation system that will provide an on-demand, point to point, passenger air service with flights that will be operated between rooftop vertiports throughout cities. It is good to note that if UAM vehicles will be used for daily commuting from rooftop vertiports throughout cities, there will be a need for strict regulation on the allowable noise level from the aircraft. Lindley (1968) noted that the location of vertiports close to city centers is dependent on the extent to which VTOL aircraft noise can be reduced. As regards privacy issues, there will be a need for regulations on how close the UAM vehicle can be to various residences. Hence, some of the policy questions that need a careful attention here are:

(1) Does the UAM vehicles that we have at this moment meet an acceptable noise level to be operated for various routes within the city?
(2) Have adequate standards been established to specify the limit of closeness of UAM vehicles to private residences to reduce the potential noise impacts and also not infringe on people's privacy?
(3) Do we have adequate systems in place to ensure that the UAM vehicles will refuse to move closer to the privacy boundaries of people's dwelling places even if the pilot intends to ignore any regulation that may be established in this regard?

4.4. Establishment of appropriate search and rescue operations, and alarm systems

Adequate, and well-equipped search and rescue team needs to be established in various municipalities before flying car system is legalized in large amounts in various municipalities. This may include facilities to bring down the car if emergency landing is done on unexpected places such as an accidental emergency landing on a roof top, a car hanging on a tree, etc. Adequate rescue facilities should also be in place if the flying car accidentally lands in a body of water. It will also be desirable to see that all flying cars comes with automatic alarm systems to notify law enforcement officers of dangerous conditions. Even if the occupant of a flying car does not have a telephone at hand, emergency alarm system should always be available on board to notify designated authorities about dangerous situations, and the need to have rescue efforts in readiness. In case of emergency landings close to private residences, it will be a good idea to have options that will automatically alert the local security personnel of such intent of emergency landing, to ensure adequate emergency services are provided. If a community is not prepared for such services, it may not be a wise idea to legislate large scale use of UAM vehicles until the community has adequate facilities to handle any emergency situation that may arise during UAM transportation. A policy decision here will be to evaluate the readiness of the community as regards establishment of an efficient team for search and rescue operations for flying cars in UAM system.

4.4.1. Cyber Security Protections

For autonomous motor vehicles, the issue about misuse and hacking of software has been raised in the literature. Kyriakidis, Happee, & de Winter (2015) presented some findings of public opinions on automated driving and noted that respondents were mostly concerned about software hacking/misuse. Respondents were also concerned about safety and legal issues. This issue could also be of concern for autonomous flying cars. Mofolasayo (2018) in his presentation at the Canadian transportation research forum proposed some solutions for addressing the issue about software hacking/misuse in autonomous driving. Some of these includes:

- Improving on security system that can quickly identify data breach and prevent hacking.
- When a data breach has been identified, the system to be implemented and maintained should be such that can promptly inform users and refuse to work in autonomous mode etc.

It is important to ensure that adequate systems exist that can help to prevent abuse of flying car systems in UAM systems. The suggestions above may be carefully addressed. It may not be a good idea to legalize autonomous flying vehicles in large quantities in any community if the system can be easily invaded by any software hacker. More research is recommended on the above recommendations and to adequately address the issue about cyber security for urban air mobility systems.

5. Establishment of sustainable finance system

Sustainable financing is a critical issue for transportation. Although flying car technology systems can be designed in such a way that the traditional roads will not be needed, there is still a need to establish adequate systems to generate funding for purchase, and maintenance of relevant technological infrastructures to keep the system running smoothly and safe for everyone. If any community rely on funds from toll gates, for construction and maintenance of road networks, what will happen if there are many flying cars in the community that can switch to the VTOL system to avoid tolls? Possible solutions to this may involve including additional fees in the yearly registration fees for any car that is equipped with flying abilities, to ensure that these cars contribute their fair share to both technological infrastructure for air transportation, and transportation on land. Other research recommendations for this includes investigating appropriate ways to separate kilometers travelled in the flying mode from the kilometers travelled on traditional roads, and ensure appropriate billing for distance travelled on road, and equitable billings that will be adequate for maintenance of technological infrastructures for air travel. Development of good infrastructure is crucial for traditional transportation systems. Ensuring that sustainable finance systems exists for infrastructure development and maintenance is also crucial.

6. Power system for vertical take-off and landing

The issue of adequate power systems for flying cars is one that requires a careful attention. Various concerns exist on the issue about power systems for transportation works. While it will be good to pay good attention to issue about air pollution and conservation of natural resources, it is also good to pay a good attention to the financial impacts of various energy choices on the economy of different communities globally. A system that ensures a balance in various interest on the choice of energy and sustainability is recommended. This area will benefit from an open and unbiased research. An important factor to also consider in the choice of energy supply for air travel operations is the ability to achieve a safe design to prevent explosion of the air craft during a period of mechanical fault or during crash landing situations. From all factors to be considered here, safety of people in the transportation medium takes the highest priority. Hence, research in this area is a very important task.

In a list of potential benefits of Lift+Cruise VTOL aircraft, Silva & Johnson noted that electric motor propulsion system with large number of rotors will enable the aircraft to be operated at a low tip speed. This is expected to result in a decrease in noise level when compared to an aircraft with fewer large rotors. Kohlman & Patterson (2018) on a study about transportation modeling and determination of energy-related constraints for system level urban air mobility gave some advantages of using liquefied natural gas (LNG) as a fuel in a hybrid solid oxide fuel cell-battery turbine system over pure battery-electric power solutions at the same power level. This present study is not meant to evaluate the technicalities of the power system for vertical take-off and landing. In any case, it is important to ensure that flying cars, have adequate energy for take-off, in-air, and landing operations.

Before approval of flying cars system on a large scale, it will be a reasonable idea to ensure that airworthiness approval systems have requirements for all flying cars to have reliable system that will determine if the amount of energy in the system before take-off will be sufficient to guarantee adequate energy for take-off, in-air and landing operations. In a system like this, operators may be required to input the intended destinations before take-off to enable the system to determine if the available energy will be enough for the travel. It will not be a desirable thing to see cars falling from the air because they have run out of energy. It will be a good idea for every jurisdiction to evaluate the energy systems in their jurisdiction to determine what will be the most reasonable energy system that can efficiently support the transportation systems in their community. If flying car technologies will be considered on a large scale in an urban air mobility system, one of the important policy questions here will be, “do these flying cars have reliable technologies that can determine if the available energy in the flying car will be enough to guaranty sufficient energy for the journey”? It will not be a wise idea to approve flying car technologies on a large scale without ensuring that all those vehicles have efficient technologies to ensure that the flying cars do not run out of power supply in the air.

7. The need for adequate environmental impact study in various municipalities

Detailed environmental impact assessment of having numerous flying cars in the air needs to be done in various jurisdictions. This may include potential impacts on air quality, if flying cars that are powered by fossil fuels are to be used. The possible impact of sending numerous cars into the sky, on the birds of the sky also needs to be considered.

According to Bird Canada, while many birds in Canada stay all year long, Canada also have millions of migrating birds that come to the lakes and forests of Canada during the spring to nest and reproduce, before returning south in the fall. Venter et al (2006) on a study about endangered species in Canada, quantified threats facing 488 species that were classified as either extinct, endangered, extirpated, special concern or threatened, and found that habitat loss is the most common threats. Other threats include overexploitation, native species interactions, natural causes, pollution, and introduced species. Agriculture and urbanization were also found as the most common causes for habitat loss and pollution. While we cannot stop agriculture and urbanization, it will be good to evaluate how to minimize the impact of human actions on the entire ecosystem. In the case of migratory birds, one of the questions to ask during policy reviews of environmental impact is “will many of these birds return to the usual place where they nest and reproduce during the spring if they face increasing threats by flying cars? For the endangered birds, will increasing the number of flying cars drive these birds to extinction more easily?

If having flying cars in a certain community is not found to constitute significant threat to the birds of the air, after all other concerns must have been adequately addressed, giving that humans do not live in suspended structures in the air, there is a lot of space that can be utilized for efficient transportation in the air. Gaston and Blackburn (1997) estimated the global population of birds as between 200 and 400 billion. Yet, there is space for every bird to move freely in the sky. Note that an environmental impact study is expected to be elaborate. Every item in the environmental impact assessment for flying cars will require a careful review in various communities.

In this report, various potential area of research opportunities that may be an issue for policy approval of flying car technology has been highlighted. Previous study (Kohlman & Patterson, 2018) has also noted that before the community's vision of safe, affordable and widespread urban air mobility system can be realized, there is need for more research and development in a lot of areas including airspace operations, acoustics, vehicle design, etc. It is recommended that various policy questions highlighted in this report be given adequate consideration when discussing about approval systems for flying car systems in every community.

Conclusion and recommendations

Flying car technology system is a technology with great prospects to help alleviate the issue of road traffic congestion, by reducing the reliance on traditional roadways. Associated cost to construct, and maintain traditional roadways may also be highly reduced. This study presents potential benefits, and review of some of the potential policy issues with flying cars systems. Some previous works relating to urban air mobility was reviewed. Various recommendations, and research opportunities for the air transportation industry were discussed in the paper. Given the additional privilege that flying cars will have over traditional automobiles, and the ability of these cars to fly to a reasonable distance close to people's place of abode, before large scale approval of flying car technology, it is recommended that various potential policy issues that have been highlighted within this paper be given adequate attention. These includes: the need to ensure that reliable systems exist that can determine if the flying car has enough energy to support the take-off, in air, and landing operations without running out of power supply whilst enroute, the need for technological innovations to minimize the impact of mechanical faults or accidents from flying cars, the need to ensure mandatory collision avoidance systems for flying car technology, the need to ensure appropriate tracking systems for flying cars, the need to ensure strict maintenance requirement and periodic air worthiness test for flying cars, the need for adequate law enforcement systems to control misuse of the technology, the need for establishment of no-fly-zones, flight paths and manuals, the need to establish appropriate search and rescue operations and alarm systems, the need for establishment of sustainable finance systems for the technology, the need for environmental impact study in various municipalities, etc.

If a community does not have adequate infrastructure and technology to ensure safety of people both on the ground and in the air in a flying car era, the flying car system is not recommended for such a community. It is hoped that this review will generate more research interest in flying car technology systems. It is also hoped that this report will be highly helpful for planners, developers of urban air mobility transportation vehicles, and policy makers in various jurisdictions globally.

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