FROM HOBBY TO HAZARD: ADRESSING THE OVERPOPULATION OF DOMESTIC DRONES IN THE NATIONAL AIRSPACE

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ABSTRACT

Domestic drones are becoming more and more popular in the United States. The FAA did not expect the exponential boost in drone presence within its airspace in the first half of 2015. Drones have now become a safety concern for manned flight throughout the country. This paper will explain why there is overpopulation in the airspace and provide recommendations to help remedy the problem. Due to market innovation, lax regulations, and genuine curiosity, the market for the drones has grown quickly. As materials become cheaper, more competition is allowed to enter the market. With prices going down, demand is increasing. The FAA will need to create regulations that will act quickly to address the problem before it is too large to handle. This paper recommends that the FAA mandates registration of all drones in the airspace and create geo-fences to keep drones out of safety hazard zones.

INTRODUCTION

Background

Unmanned Aircraft Systems (UAS) or "drones" are becoming a threat to domestic airspace security. In 2014, there were 238 reported near accidents or drone sightings above their legal elevation ceiling[1]. Between the months of January and August 2015, there have been 650 similar situations[1]. That is a 173% increase within the first half of this year. With these staggering numbers, there has been increased pressure put on the Federal Aviation Administration (FAA) to create new policies to contain the rapidly evolving domestic drone market. The FAA estimates that there will be more than 30,000 UAS in our airways by 2030[2]. The market is rapidly increasing and the FAA needs to speed up its policy making pace. Commercial drones, which are used for research and other non-personal uses, need to obtain FAA authorization to be able to fly[3]. The owners have to provide detailed information on the drone's design and also on the purpose of its use[3].

The regulations currently state that the person in command of the drone must possess an airline transport license, which may be commercial, recreational, private, or a sport pilot certificate[4]. They must also hold a valid US driver's license or a current FAA airman medical certificate[4]. This makes it easier for the FAA to track commercial UAS use and also a method of limiting it. There are looser guidelines for recreational drones. There are suggested guidelines on the FAA website, but recreational users do not have to register their UAS. One of the guidelines states that the drone is not to be flown within five miles of an airport, without airport consent[5]. Of the 650 cases of near accidents or sightings, 552 of them had the distance from an airport recorded, and out of the 552 reports, 58.6% of them occurred within five miles of an airport[6]. Another guideline states that the highest altitude a personal drone can be flown is 400 feet. There were 627 cases in which the altitude was recorded and 90.1% were above the recommended 400 feet[6].

1"Drone Sightings and Near Misses." Center for the Study of the Drone. Bard College, 28 Aug. 2015. Web. 17 Sept. 2015. <http://dronecenter.bard.edu/drone-sightings-and-near-misses/>.

2 Barbee, Melissa. "UNCHARTED TERRITORY: THE FAA AND THE REGULATION OF PRIVACY VIA RULEMAKING FOR DOMESTIC DRONES." Administrative Law Review 66.2 (2014): n. pag. Web.

3"Civil Operations (Non-Governmental)." Federal Aviation Administration. Federal Aviation Administration, n.d. Web. 17 Sept. 2015. <https://www.faa.gov/uas/civil_operations/>.

4"Section 333 Frequently Asked Questions (FAQ)." Federal Aviation Administration. Federal Aviation Administration, n.d. Web. 17 Sept. 2015. <https://www.faa.gov/uas/legislative_programs/section_333/333_faqs/#q12>.

5"Civil Operations (Non-Governmental)."

The biggest concern with the current guidelines is that we are still seeing the majority of recreational users in violation of them. If left unresolved, this issue will only become worse as drone numbers increase, especially as they are becoming cheaper to produce and more available to the public[6].

Major Causes/Contributing Factors

The systems map, in Fig. 1, illustrates major contributions to the problem. The four main categories are: policies, market innovation, actors, and material/equipment. The policies show inconsistencies among the different uses of domestic drones. Section 333 of the FAA Modernization and Reform Act (FRMA) outlines the requirements necessary for a UAS to be granted grant flight permission[7]. UAS used for commercial/business purposes may be granted an exemption to Section 333 if they provide extensive information describing the drone, its purpose, and who will be piloting it. The numbers of exemptions are recorded in the FAA's database and businesses cannot re-use an exemption for another drone they own[8]. A special certificate can be granted to a UAS used for experimental purposes. The experimenter will have to provide the FAA details on their experiment, how long it will be happening, and on the UAS itself. The FAA then determines if it is okay for the UAS to operate[8]. The inconsistency occurs with the recreational drone use policy. Consequences, for violating safety regulations, are not being enforced. Under current policies, these drones do not need permission from the FAA to fly.

Drones are becoming easier to make and operate, and the materials used to create them are easy to obtain[9]. They use common materials which will be attractive to producers who want to enter the market at a relatively low cost[9]. The U.S National Airspace System (NAS) is a very complicated entity, in which any unpredictable change in activity can result in an accident[10]. This complication contributes to why the introduction of more drones than expected is adding to the problem. Market innovation has changed the options available for aviation services. Different jobs that people would hire pilots for could be done for a lower price with a UAS. There are also different uses for UAS, due to the expansion of the market[9].

7"Section 333 Frequently Asked Questions (FAQ)."

8"Section 333 Frequently Asked Questions (FAQ)." Federal Aviation Administration. Federal Aviation Administration, n.d. Web. 17 Sept. 2015. <https://www.faa.gov/uas/legislative_programs/section_333/333_faqs/#q12>.

9 Barbee, Melissa. "UNCHARTED TERRITORY: THE FAA AND THE REGULATION OF PRIVACY VIA RULEMAKING FOR DOMESTIC DRONES." Administrative Law Review 66.2 (2014): n. pag. Web.

The main actors also contribute to this problem. UAS operators are not following current regulations, which greatly impacts the safety of the NAS. Manufacturers may not be doing their part to inform their consumers about proper use of their drones. Manufacturers are also selling more drones this year than past years, which means that the uninformed public is increasing in size. The FAA has not been quick to create a more comprehensive measure for regulating the market. To address things properly, the FAA should pursue a policy that combines mandatory registration and the installation of geo-fences for recreational drones.

PROBLEM SCOPE

This issue fits into several failure frameworks. To begin with, there are negative externalities that result from the exponential increase in the use of drones. These externalities include damage costs to manned aircrafts if there is an accident, increase in "visual pollution" if there are too many drones in the sky, and loss of job opportunities for pilots of manned aircrafts. Different jobs that are typically given to pilots would be diverted to drones. Examples include crop dusting on fields or aerial photography at an outdoor event. With the last externality in mind, this could lead to rent seeking on behalf of pilots. Positive externalities can result from job diversion, especially in the research field. Drones can be sent to dangerous areas that would be unsafe for a manned aircraft, and this can lead to new discoveries. They can also lead to a new set of job availabilities, since commercial drones require that the person flying them has a pilot license[11].

There is also an issue with uncertainty in the form of moral hazards. When consequences are not given to drone users for violating the guidelines, they will continue to engage in the same risky behavior. This behavior can lead to accidents and also misinformation to their peers. When the FAA created regulations for commercial and recreational drone use in the past, the market was not as large as it is now. It is possible that a lack of foresight could have led to this allocative inefficiency when creating current drone policies, or it could have been genuine uncertainty about the market's development. On top of the safety concern in the airspace, there are also privacy concerns among civilians.

10 Google UAS Airspace System Overview (n.d.): n. pag. NASA. NASA. Web. <http://utm.arc.nasa.gov/docs/GoogleUASAirspaceSystemOverview5pager[1].pdf>.
11 "Civil Operations (Non-Governmental)."

There is an ongoing conversation about whether or not the FAA is the right entity to address privacy concerns associated with drones[12]. The FAA has solely been responsible for the US airspace and its safety, but not civilian privacy. Without the help of other departments focused on privacy, this leads to a lack of cooperation and coordination.

POLICY OPTIONS

Status Quo

Recreational UAS currently do not require any permission from the FAA to fly. There is a list of regulations set forth by the FAA to establish safe flight boundaries. The regulations state that drones are not to fly within 5 miles of an airport, and must fly below 400ft[13]. The aircraft must also remain within sight at all times, and cannot be flown around people or stadiums. If operation of the drone results in the endangerment of people or other aircrafts, the operator may be fined[13]. The problem with the status quo is there has been lax enforcement. People are not being tracked down when their drones are found in unauthorized areas. Fines are not being administered, so the reckless behavior has been continuing.

Mandatory Registration[14]

New drones will come with a unique identifying marker or chip that is connected to a unique registration number. Upon purchase, consumers would have to register their information to link with their drone. The FAA will create a database to contain all of this information. For older drones, an identification sticker will be mailed to the owners from the manufacturer. If you created a drone yourself, you can request a registration code from the FAA. The FAA will set forth a day in which all drones have to have some sort of marker on them, or they will be confiscated. Ideally, if a drone is found in a "no-fly zone", then the owner can be tracked down and fined accordingly. This should discourage inappropriate drone use.

Geo-Fencing

New drones would have a chip installed that contains geo-fence boundary instructions.

12 Barbee, Melissa. "UNCHARTED TERRITORY: THE FAA AND THE REGULATION OF PRIVACY VIA RULEMAKING FOR DOMESTIC DRONES."
13 "Model Aircraft Operations." Model Aircraft Operations. Federal Aviation Administration, n.d. Web. <https://www.faa.gov/uas/model_aircraft/>.
14 Task Force Recommendations Final Report. Rep. Federal Aviation Administration, 21 Nov. 2015. Web. <https://www.faa.gov/uas/publications/media/RTFARCFinalReport_11-21-15.pdf>.

Geo-fencing is part of a software program based on GPS coordinates[15]. It is a virtual boundary that would cause a drone to cease function, when crossed. With this in place, drones would be prevented from going too high into the sky and too close to airports. The FAA can also go the extra step and have virtual fences around major stadiums, government buildings, and other high profile locations. For older drones, there would have to be a subsidy given to manufacturers to allow them to install the chip. The FAA can also put together a team in different areas that can install a protected exterior chip, which would just contain the geo-fence software, if manufacturers are unable to do it or the drone is self-built. A date will be set force for all drones to contain geo-fence software. Non-compliance can result in confiscation.

Mandatory Training with Licensure

The FAA will create a standard curriculum that each drone training program has to follow. This would be similar to the process of receiving a driver's license. Consumers who wish to purchase a drone will have to watch an instructional video going through the basic information on regulations. The video will be administered at a registered testing site and the site will also give a short quiz covering the key points. To go along with the instructional video, there will be an aviation test in which participants will practice using a drone, so they have some knowledge of how one flies before obtaining one. Producers would request the ID number of the course completion license before selling a drone. After that, the ID number will be linked to the drone, and the owner can be contacted if the drone is being used inappropriately. Similar to getting points for tickets and traffic stops with your driver's license, the drone license would also receive points for each misdemeanor. After a certain point threshold, the owner will have to attend remedial courses or face having their license confiscated.

CRITERIA/INDICATORS

The first policy goal will be to maintain safety in the airspace. The criteria will include reducing the number of drone near-misses in the airspace and reducing the number of drone sightings in the "No Drone Zones" around airports. While "No Drone Zones" can be designated to many areas and events, airports are consistent in location and therefore provide an easy form of tracking any changes to last year's sightings report.

15 Rouse, Margaret. "Geo-fencing (geofencing)." Whatis.com. Whatis.com, Sept. 2015. Web. <http://whatis.techtarget.com/definition/geofencing>.

Near-misses are not airspace accidents, but close encounters in the air. These could be measured over time by pilots and compared to last year's numbers under the status quo policy. The second goal will be to maintain steady market growth. None of our policies should push towards shutting down the market, because domestic drones have been shown to be beneficial for many things[116]. Our goal should be to steady the growth of the market, so it is easier to regulate. The criteria for this would be the barriers to market entry and the percent change in drones sold.

Our third goal is to minimize the cost of implementation. The indicator for this criterion will be general estimates of how much each policy option will cost to implement. The estimates will show which costs are shared by both consumers and producers. Costs estimates also tie into our fourth goal, which is the examining feasibility of the policy. The criteria for this are public acceptability, and technical feasibility. For public acceptability, we will take note of possible effects of the policies on consumers and producers. It is important to understand how the public will respond to a policy change because for the policy to be effective, the general public must be willing to adhere to it. The indicators for technical feasibility will depend on the policies chosen. It will be determined if we have the current technology to implement any modifications to the drones, if necessary. It is also important to take note of whether all drones have the capacity for further modifications, since there are many types.

OUTCOMES

The outcomes matrix in Fig. 2 shows a comparison of each policy option in respect to how well they fit the criteria for each goal. The status quo policy serves as a comparison baseline for the other options. All cost projections will be relative to the status quo budget. Mandatory registration will have a low/medium effect on reducing the amount of near-misses and drone sightings. It is highly dependent on how many people follow the policy and how many people are deterred by the possibility of being fined.

The FAA will incur a low cost of implementation because creating a database is not new technology. They already have a database that holds information on commercial drones used for business. Producers will also incur a low cost for creating a unique identifying marker, which may be a sticker or physical marker. Consumers will be sacrificing a bit of their time to register, but registration will ideally be a quick process. There

[16] Jenkins, Darryl, and Bijan Vasigh, Dr. The Economic Impact of Unmanned Aircraft Systems Integration in the United States.Publication. N.p.: n.p., n.d. The Economic Impact of Unmanned Aircraft Systems Integration in the United States. Association for Unmanned Vehicle Systems International, Mar. 2013. Web <http://www.auvsi.org/auvsiresources/economicreport>.

are minimal barriers to market entry with this policy, due to producers having to do a light modification to their designs and there will also only be a slight reduction in the amount of drones sold. The process of linking a registration number with a person's information can be easily done and because there are other lifestyle technology that require linking information, the public should be accepting of this policy. There may be a few privacy concerns, but not in the majority. Mandatory registration will also address the moral hazard issue. People will have more responsibility, so they will be less reckless with their drone usage.

Geo-fencing produces a large reduction in the number of near-misses and drone sightings. With the virtual fence in place, it will be difficult for any chipped drone to go past the boundaries. Costs will be high for the FAA because they will have to develop the basic software parameters and also have a plan in place for long-term maintenance of these boundaries, if they change. Producers will incur a medium/high cost, depending on how large their company is, because they will have to create and install a GPS chip that fits the FAA's standard. There is also a chance that many drones have a GPS chip in them already, for navigation purposes, which will make it easier to install the geo-fence software. Costs of production can be shifted on to consumers, increasing the market price of drones. There will be some barriers to market entry because drones that do not fit the new market standard will not be marketable. Smaller companies may opt out of getting into the market. There will be a medium reduction in the amount of drones sold due to fewer producers in the market and a higher selling price. A geo-fence is feasible to implement with our current technology, but the problem is figuring out how to standardize the software, what effect they want to occur when the drone hits a fence, and where boundaries should be placed. In terms of public acceptability, it will be on the lower end or towards the middle, depending on how widespread public outrage is from hobbyists and those who feel that their freedom is being restricted.

Mandatory Training with licensure will have a medium reduction in near-misses and drone sightings. Implementation costs will be low, since it's just a matter of finding staff to administer and create training programs. Costs of creating new licenses will be included as well, unless the FAA opts to have a digital license. Producers and consumers will both have minimal costs. Consumers will have to pay a fee for the license course, but since it is a short program it will not be a large sum. There will be minimal market entry barriers because the drones will undergo a slight modification, like with registration. A license mandate also comes with an age requirement, and this will lead to a medium reduction in the amount of drones sold.

Some consumers may not be willing to invest time in the training program. A training program is technologically feasible; we already have similar ideas in existence. The age restriction might bring some public backlash, but creating a new job market will boost public acceptability. The new job market would consist of people that administer the training programs. This also doubles as a positive externality of this policy as well.

RECOMMENDATION

Geo-fencing gives the most promise for increasing the safety in the airspace, but . it is also the most expensive to implement and holds a higher risk of public backlash. Geo-fencing also helps to stabilize the market by reducing the amount of drones sold by the most. Mandatory registration holds the lowest costs, but does little for increasing safety and market stabilization. Registration is the easiest to implement and more acceptable with the public. Mandatory training with licensure holds the risk that people will not want to invest time into the training program, but it does have a larger effect than registration on increasing safety. While mandatory training will have a similar effect as geo-fencing on decreasing the amount of drones sold, it does not help with creating barriers to market entry. With all of this in mind, the recommendation is to combine mandatory registration and geo-fencing.

This recommendation stems from the fact that mandatory registration can be implemented in the short-term, and geo-fencing in the long-term. In the time it takes the geo-fence to be implemented, consumers can be properly informed on what a geo-fence is and how it can actually help save them from being accidentally fined. This will help minimize any public backlash. Mandatory registration requires a unique identifier and this can also be the GPS chip used for geo-fencing. Ideally, the mandatory registration will boost the compliance effects of the geo-fence. Figure 3 shows a logic model utilizing the combined policy option. The logic model gives the policy combination a better platform to work with because it shows how compliance with the geo-fence actually helps consumers. Fine protection from the geo-fence will help counteract any negative thoughts about mandatory registration being a source of income. The combined effort gives a lot of different ways to increase the safety in the airspace, which is our largest goal. The logic model is limited due to working off assumptions that may not be the actual reality of what will happen if implementation occurs.

APPENDIX

FIGURE 1: SYSTEMS MAP

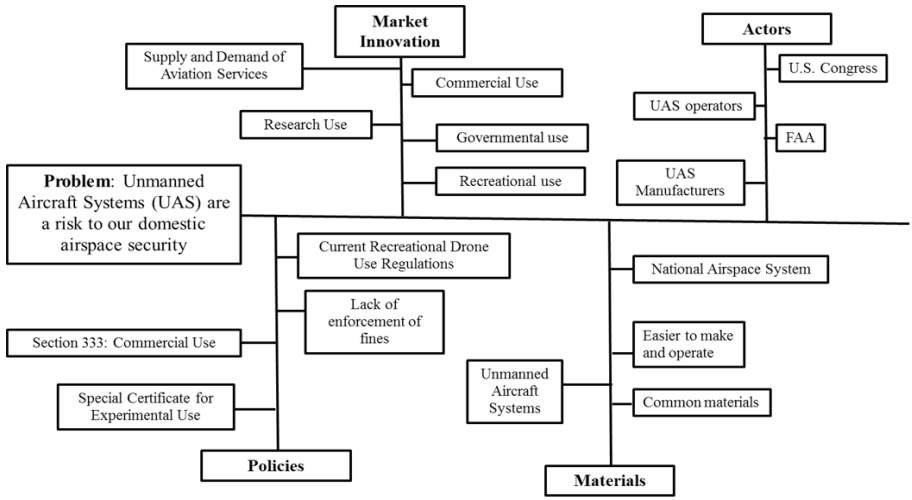


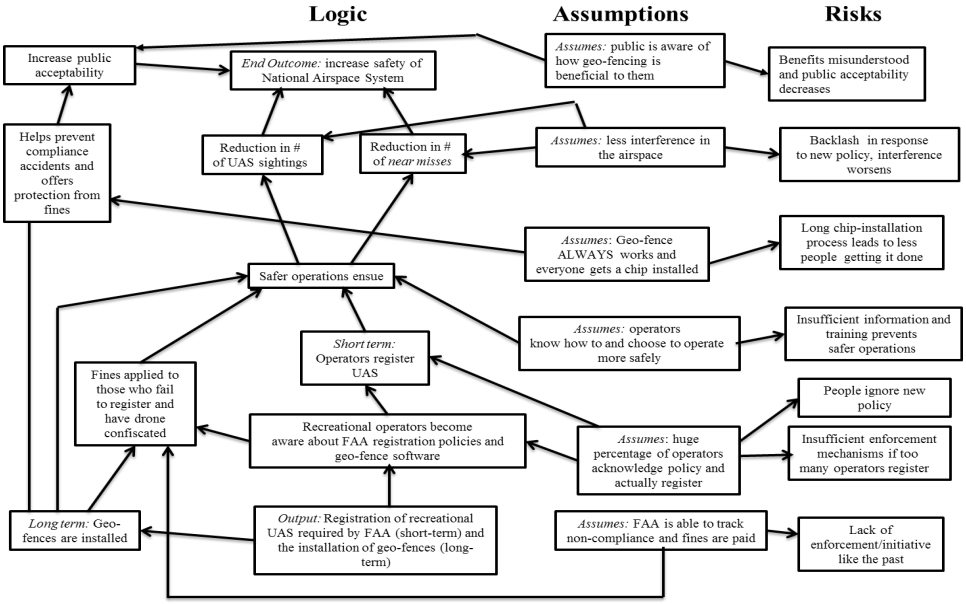
FIGURE 2: OUTCOMES MATRIX

Goals	Criteria	Policy Options			
		Status Quo	Mandatory Registration	Geo-Fencing	Mandatory Training with licensure
Maintain Safety	Reduce number of near-misses	Baseline	Low/medium: registration may cause people to look up information on regulations to avoid being fined	High: drones will be fenced out of areas	Medium: Training leads to regulation education
	Reduce number of sightings in a "no drone zone"	Baseline	Low/medium: people become more aware of no drone zones and keep their distance	High: drones will not be able to enter the zone	Medium: Training leads to regulation education
Cost to implement	Monetary	Baseline	Low: cost of creating a database to hold and maintain all the information	High: cost of employees to define boundaries, and long-term maintenance	Medium: finding staff certified to create/ administer training program and cost of creating new licenses

Cost to consumers/ producers	Monetary	Baseline	Producers: (low) cost of creating a unique identifier for the drone Consumers: (low) time needed to register	Producers: (medium/high) cost of installing technology in drone that abides by geo-fence regulations Consumers: (low/medium) costs shifted from producers	Producers: (low) cost of creating a unique identifier Consumers: (low) extra fee for license & training program
Steady Market Growth	Barriers to market entry	None	Low: slight modification to the drone, so companies should not be deterred	Medium: modifications may deter smaller companies with less capital for business	Low: slight modification to the drone, so companies should not be deterred
	Change in % of drones sold	Baseline	Low reduction: some consumers may have a privacy concern, but not large enough to have a significant change in the % sold	Medium reduction: mainly in part from less producers in the market	Medium reduction: with licensing comes an age requirement, and some consumers may not be willing to invest time in the training program
Feasibility	Technical Feasibility	High	High: modifications can occur with relative ease, just need time	Medium: figuring out boundaries, authorizations, which geo-fence effect to use on the drones (shut-down or retreat)*, how to standardize drones to oblige	High: training videos/ programs are made all the time for different types of machinery; license creation is not difficult
	Public Acceptance	High: Note, due to the number of regulation violations, it is possible that many people do not know of the current policies	Medium/High: people already register other hobby/lifestyle technology under their name (FitBits, tablets, etc); no extra fee to register, but possible privacy/tracking concerns	Low/Medium: restriction of freedom of use; outrage from producers and hobbyists who create their own drones	Low/Medium: age restriction may cause public outrage and hobbyists will be unhappy; new job market creation may lead to increased acceptance

*Shut down or retreat means that they have to pick between the drones automatically shutting down when they hit a geo-fence or the drone simply retreating away from the fence. The latter being the more ideal for the feasibility goal.

FIGURE 3: LOGIC MODEL



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