FEASIBILITY ANALYSIS OF UAV IN DENGUE CONTROL

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ABSTRACT

There are intensifying actions to combat the mosquito Aedes which is admittedly responsible for the transmission of diseases: chikungunya, dengue and zika. Among these dengue is a recurring problem that affects the entire world, especially the tropical areas. It is considered one of the world's greatest public health problems by the World Health Organization, which estimates that approximately 390 million people get infected by this disease each year worldwide. In Brazil, since the first report of the disease in 80's, dengue has continually occurred, alternating epidemic periods with peaks of increasing disease. Therefore, this study aims to assess the feasibility of using unmanned aerial vehicle, popularly known as drone, in aid of the dengue control program executed the Brazilian city of Maringa - PR. The results indicate that the use of this aircraft is feasible, since it is an economically attractive investment due to its low cost against the annual investment with manpower.

Keywords: Feasibility Analysis, Unmanned Aerial Vehicle, Drone, Aedes Mosquitoes, Dengue, Zika, Chikungunya

1. INTRODUCTION

Currently there are intensifying actions to combat the mosquito Aedes which is admittedly responsible for the transmission of diseases: chikungunya, dengue and zika. Among these dengue has the largest number of records and affects millions of people around the world every year. According to the World Health Organization (WHO, 2015) about 390 million people contract the disease throughout the world each year and 96 million will develop severe cases of the disease with estimated 500,000 hospitalizations and about 12,500 deaths. In addition, WHO estimates that around 4 billion people distributed in 128 countries are constantly living with the risk of contracting the disease.

In Brazil, the first outbreak was recorded between the years 1981 and 1982 and since then dengue occurs continuously alternating epidemic periods with peaks of increasing disease. According to the Health Department of Maringá-PR data of August 2015, the city is in an epidemic situation. This was declared and confirmed by 1,281 cases, which represents a rate of 327.41 cases per 100 thousand people. In 2015 it was recorded two deaths from dengue in the city of Maringá.

In Maringá-PR, according to the Health Department of Maringa (SMM, 2013; 2014), the Infestation Index (IIP) in 2013 reached 2.0% and had 2737 confirmed cases of breeding of Aedes mosquitoes, setting up a situation of average risk of epidemic. In 2014 IIP reached 2.4% with 3596 confirmed cases, setting high risk epidemiological.

Currently, the actions developed by SSM include: routine activities field, application of fogging, people to care for creators chance of sites dengue vector, educational lectures, the basic health units campaigns, fishnet of dengue, maintenance and public sanitation, environmental and epidemiological transparency.

One of the most important factors for the success of actions is the awareness of population, however, there are many cultural factors that hinder the effective participation of all residents. No different in degree of importance, the control carried out by officials SSM coming up daily in various adversities, such as: lack of equipment security and assistance in areas of difficult access and lack of residents in homes due the business hours among others. Thus, the Unmanned Aerial Vehicle (UAV) can contribute actions currently developed, especially innovation proposition

in the process of prevention and assessment and thus minimize the suffering of the population.

In this epidemiological scenario, it is essential to intensify the control actions against this vector through investment in improving the control methods performed today, and mainly encouraging the development of new methods thus allowing a more efficient approach to the problem, and a consequent reduction of the impact of dengue in Brazil.

In this context this article is intended to present an economic feasibility analysis aimed at the usage of emerging technological equipment specifically the Unmanned Aerial Vehicle (UAV), popularly known as drone, as a support tool to agents in combat and control of emergency situations since it has a large dynamic potential and adaptability.

To this end, data were collected from the Municipal Program for Dengue Control in order to calculate the actual costs of combating the vector that transmits dengue. At the same time through internet searches investment data were raised about the acquisition and implementation of the UAV as a tool and by crossing these data an economic feasibility analysis was performed.

This paper presents preliminary results of the study of the UAV as an adjunct in actions to combat the mosquito Aedes and is structured as follows: introduction, literature review, case study, results, conclusions and references.

2. LITERATURE REVIEW

This section will present some fundamental concepts of urban service logistics, dengue, UAV, and Feasibility Analysis.

The fight against mosquitoes that transmits dengue is within the urban service scenario. The role of logistics in the urban environment aims to find solutions to urban services problems which include medical emergency, police, collection and mail delivery, firefighters, maintenance of streets and roads, street cleaning, garbage collection, public transportation, taxis, and many others as citizens' demand for better quality and quantity of these services increases (LARSON; ODONI, 1999).

Urban logistics adapt the definitions and logistics goals to the reality of cities. The goal of logistics is simple, "is to make available products and services where

they are needed, when they are desired." (BOWERSOX; CLOSS, 2010, p.19). Therefore, this work can be characterized as a problem of urban logistics in that refers to public health service and it has an emergency character.

For Guzman and Harris (2014) dengue is defined as a viral disease caused by four serotypes (DENV 1-4) and transmitted by the bite of the Aedes mosquitoes. According to the authors, dengue has evolved from a sporadic disease to a major public health problem with substantial social and economic effects because of the increasing geographical spread number of cases and severity of the disease.

For Doctors Without Borders (2015) dengue fever is an acute febrile disease systemic and dynamic with different clinical presentations and unpredictable prognosis. After the incubation period which ranges from 4 to 10 days between the bite of infected mosquitoes and manifestation of the symptoms. The disease begins abruptly and resembles a flu-like syndrome.

The world dengue scenario is complicated, the global spread of the two species of vector, Aedes aegypti and Aedes albopictus, occurs mainly in the regions media latitude, whose climate composition is mostly tropical and subtropical areas where the vector is disperse with high efficiency. (CAMPBELL et al, 2015; SIMMONS et al, 2012.).

In Brazil, dengue is considered one of the three major challenges of public health, due to the climate that favors the proliferation of transmission vector of the disease, which combined with an inordinate population growth of cities, bad sanitation among others, have made this disease a problem chronic social.

Some Brazilian cities are making use of UAVs in helping to fight the Aedes mosquito. In the city of Maringá, due to the history of epidemic cases, the inclusion of this technology it is necessary and coupled with that comes the need for a study on the UAV and economic feasibility.

According to the Department of Defense of the United States of America: UAV is a powered aerial vehicle that does not carry a human operator uses aerodynamic forces to provide air support can fly autonomously or be piloted remotely can be expendable or recoverable and can carry a lethal or nonlethal payload. (DEPARTMENT OF DEFENSE, 2005, p.1).

Among the numerous possibilities of using the UAV, the use as an aid tool in

dengue control is the main interest of this work. This form of use of UAVs, are being exploited by some municipalities of cities such as Santos and Limeira in the state of São Paulo and Chapeco in the state of Santa Catarina. (COISSI, 2015). "The goal is to locate proliferation risk areas of the mosquito that transmits the disease." (COISSI, 2015).

A feasibility study aims to find out by comparing methods if an investment will have an economic return consistent with investor expectations, and it payback time.

The logic of payback is the representation of the capital recovery time invested initially. It is obtained by calculating the number of days months or years it will take for the accumulated amount of future capital equals the amount that was originally invested. (BRUNI, 2003)

From this logic, the payback method, we can have two approaches: the simple payback and discounted payback.

3. RESEARCH METHOD

This work is of an exploratory nature and an experimental study. The experimental study follows rigorous planning. Search the steps begin with the exact formulation of the problem and hypotheses, delimiting the precise variables and subsidiaries operating in the studied phenomenon. (TRIVIÑOS, 1987). It is the following:

Question 1. Initial: It is feasible to use UAV as a tool in dengue vector control steps in Maringa - PR?

In addition to the INITIAL question, during the development process, this paper aims to answer the following questions in order to help complete the goal: The use of UAVs will bring some benefit to aid the control of dengue?

2. Knowledge of the SECTOR: divided into two simultaneous steps, i) literature review, and ii) information collection /

3. Process Mapping: where there was the mapping of all the current process dengue control in the city of Maringa, through interviews with the responsible for the sector in the SSM.

4. Identification of problems: stage where it raises the issue of process.

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5. Data collection: on-site to monitor the day to day of the dengue control process in Maringá and collect data relevant to the study.

6. Analysis of information: step in which will analyze the data collected in the follow-ups made in the field.

7. Conclusions: Step answers the research questions.

4. CASE STUDY

The case study presented in this article was developed based on the procedures relating to actions to combat dengue in the city of Maringa. Therefore, this study was methodologically structured as follows: monitoring of dengue combat teams preparing the mapping of the transmitter of dengue vector control processes registry access offside situations to dengue control agents.

By monitoring the work of the Municipal Program for Dengue Control (PMCD) was possible mapping the dengue vector control process in the city of Maringa as shown in Figures 1, 2 and 3.
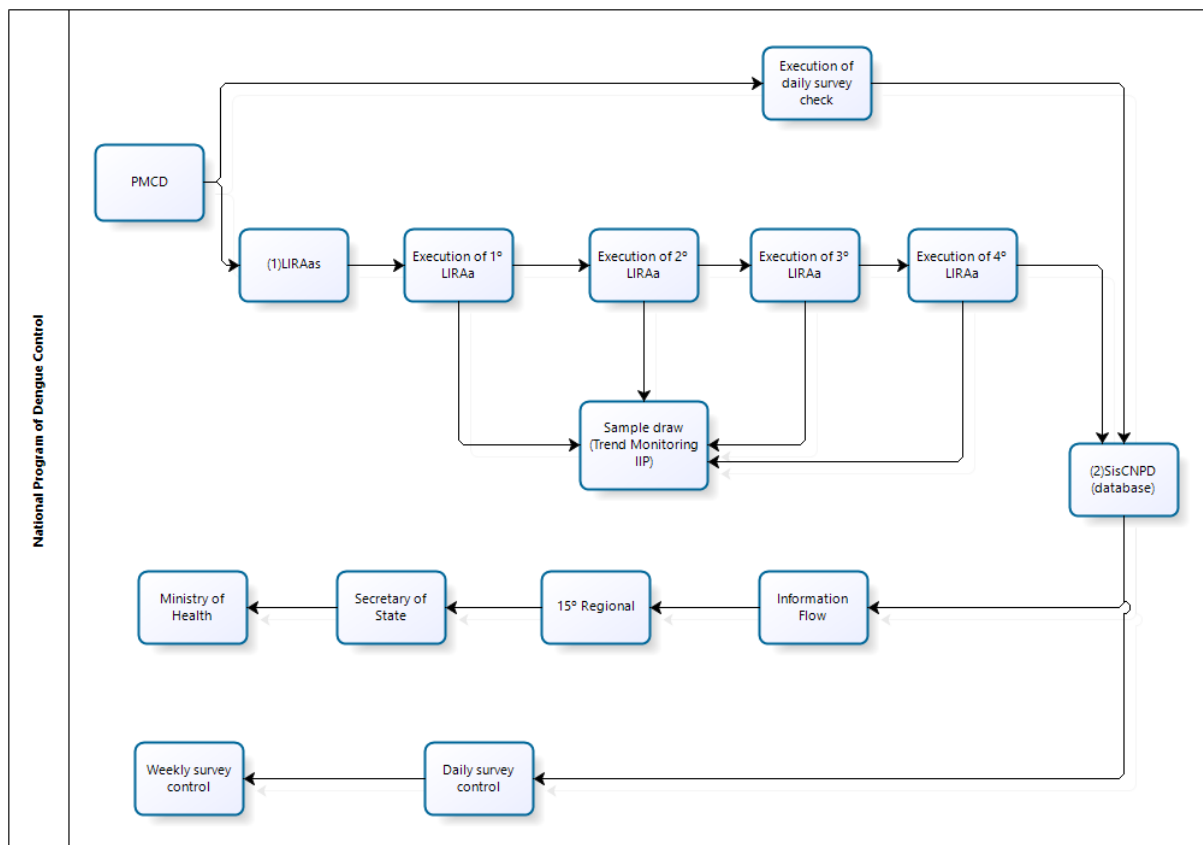

Figure 1: View from the National Program of Dengue Control

(1) Quick survey index for Aedes aegypti (LIRAa).

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(2) SisCNPD is a database where all data about survey control are insert.
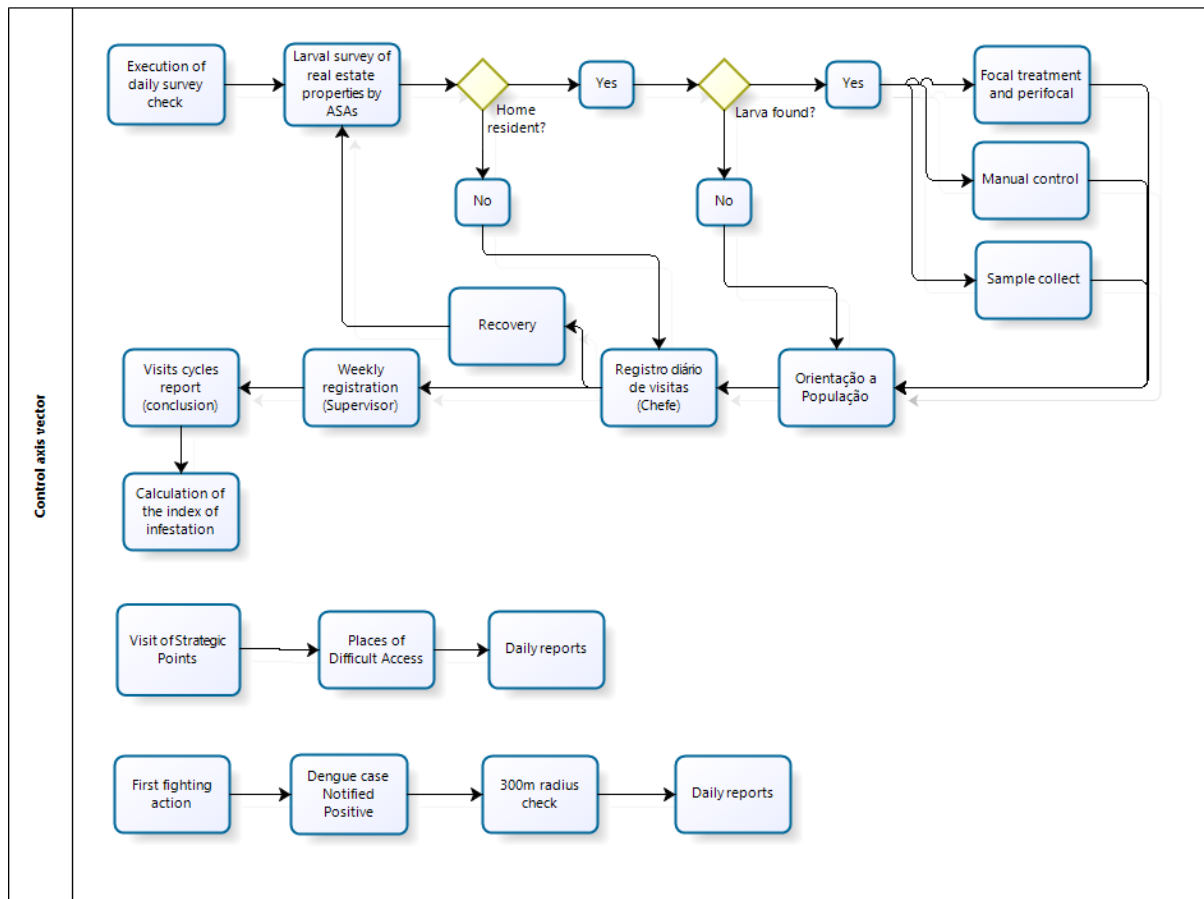

Figure 2: Map Vector Control Process

After developing the process mapping it was identified with the agents in the field, through interviews with 30 agents (including 6 supervisors, 4 team managers and 20 agents), the main difficulties faced by them on a daily basis. Among the registered difficulties, some were selected according to the subject of this article so that this process of refinement aimed to identify problems that present potential solution through the implementation of UAV as a support tool. Through the work done in the field it was possible to record real situations where the use of UAVs could be of great help especially in the stage of locating possible breeding spots of the vectors.
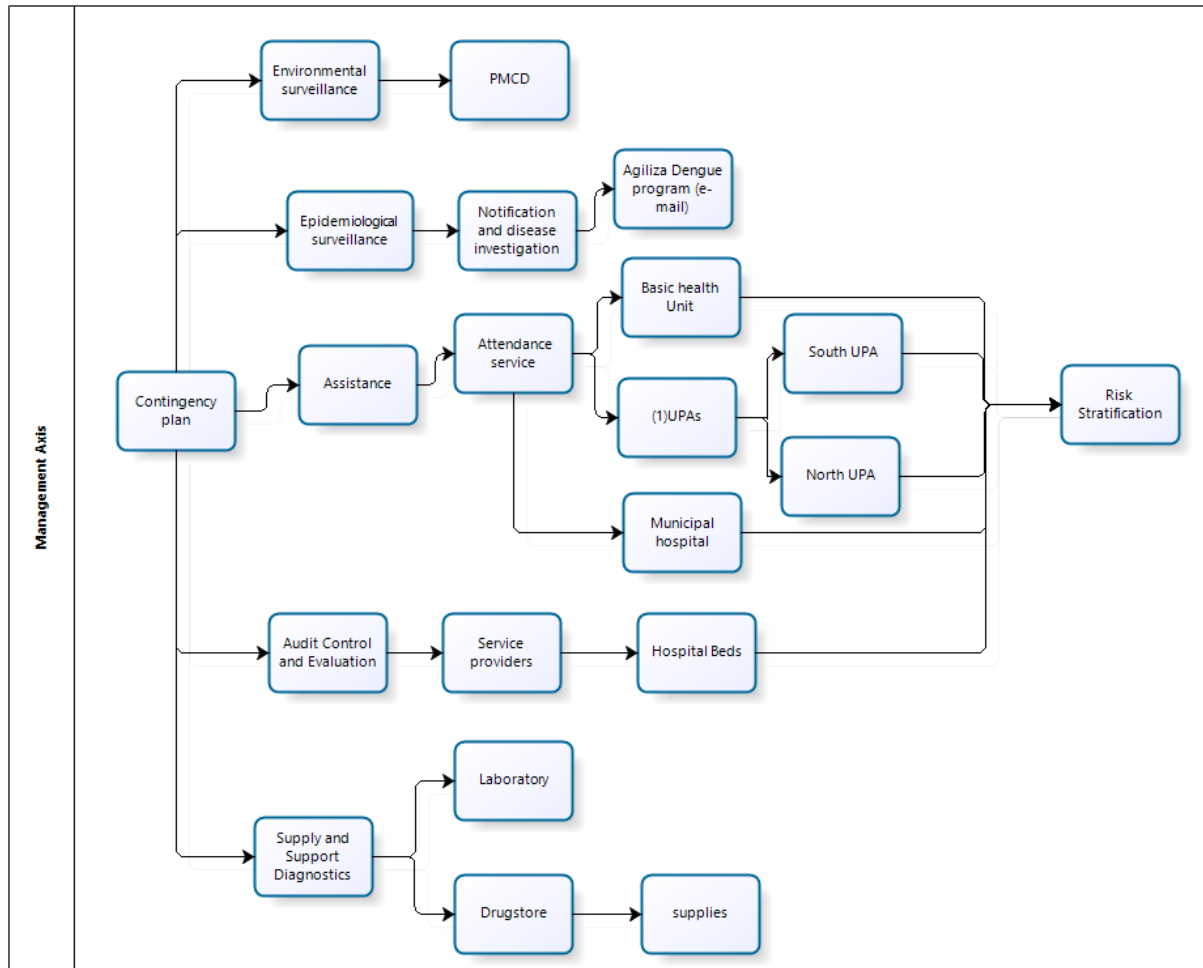
Figure 3: Dengue control, management axis in the city of Maringá

A situation of difficult access to dengue fighting agents can be exemplified by the inaccessibility, danger, and the need for consecutive visits. Figure 4 depicts the front of a field of difficult access where agents were unaware of the existence of an abandoned pool. After several inspections, the agents were able to enter on the field, however, the situation presented danger to integrity of themselves. It possible to identify a major focus of the dengue vector as shown in Figure 5.

Figure 4: Front view of the field

Figure 5: Abandoned pool

In this case it was observed that the use of UAVs can speed up the location of these potential breeding sites it can help managers to plan control measures and informed survey on data from the UAV. Thus, the dengue control method make most efficient because it is possible to direct the efforts to combat the area where the images generated by the UAV point to a high probability of occurrence of dengue vector outbreaks.

5. RESULTS

This section presents the data on the costs of agents to the SSM. Based on the information obtained by the research on UAVs the calculations regarding the economic feasibility analysis of the insertion of this emerging technology as an aid in the fight against dengue vector especially in situations with hazardous inaccessibility and consecutive visits need are presented.

Since 2005 the budget for the SSM has been raised significantly. In a period of 10 years from 2005 to 2015 the stipulated budget for SSM grew 376.18%. Of the amount budgeted for SSM in 2015 the Board of Health Surveillance (In portuguese "Diretoria de Vigilância em Saúde" or DVS) represent a share of 2.16% and of that PMCD represent 30.89%.

The largest amounts budgeted by PMCD are committed to the payroll of Environmental Health Agents (In Portuguese "Agentes de Saúde Ambiental" or ASAs) and the acquisition of Personal Protective Equipment (PPE) used by them. Each of these is 86.83% and 6.51% of the amount, respectively.

Considering that the salary of an ASA in 2015 was established on average at R$ 1,014.00 and whereas the PMCD has 210 employees spent only with the salary

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can exceed the stipulated budget for the year.

Table 1: UAV models and their specifications

DJI Phantom 3 Professional Autonomy: 25min. Range: 2km Speed: 16m/s Camera: 12MP 4k 30fps Price range: R$ 7.999,00 – 10.890,00	**DJI Phantom 3 Advanced** Autonomy: 25 min. Range: 2km Speed: 16m/s Camera: 12MP 2.7k 60fps Price range: R$ 6.999,90 – 9.719,00	**AR.Drone 2.0** Autonomy: 18 – 36 min. Range: 50 – 100m Speed: 11m/s Camera: 720p 30fps Price range: R$ 2.100,00 – 2,399,00
DJI Phantom 2 Vision Plus Autonomy: 25 min. Range: 300m Velocidade: 12m/s Camera: 14MP 1080p 30fps Price range: R$ 6.499,90 – 6.999,90	**DJI Inspire 1** Autonomy: 25min. Range: 2km Velocidade: 22m/s Camera: 12MP 4k 30fps Price range: R$ 17.799,90 – 17.990,00	

Analyzing the specifications of UAVs shown in Table 1 it was decided to serve as a calculation parameter in this work the DJI Phantom 3 Advanced model since it has good autonomy great range great flight speed and excellent camera / video camera in compared to the others.

In the UAV costs were also considered the costs necessary to train an agent to operate and analyze the generated images. Through market research was possible to select a course that meets the skills required for a UAV pilot for the type of service that is required in dengue control, mapping, imagery analysis and tracking possible outbreaks. The amount of investment required in this type of training is R$ 2,299.00 (2015 values).

With these data it was possible to make some comparisons between the costs of agents and the UAV to combat dengue vector. Tables 2 and 3 confront the values obtained for UAV and ASA for daily flight configurations of 1 and 2 daily flight pre-

established.

Table 2: Comparison between UAV and ASA on a 1 daily flight configuration

	Number of daily flights	UAV	ASA
*Invested in a year (R$)	1	9.719,00	13.182,00
*Traning (R$)		2.299,00	-
Surveyed area per year (km²)		55,55 - 663,30	3,04
cost of km² surveyed (R$/km²)		18,12 - 216,35	4.336,18

*These values represent only the spend in the year of purchase of the UAV.

Table 3: Comparison between UAV and ASA on a 2 daily flight configuration

	Number of daily flights	UAV	ASA
*Invested in a year (R$)	2	9.719,00	13.182,00
*Traning (R$)		2.299,00	-
Surveyed area per year (km²)		111,09 – 1326,60	3,04
cost of km² surveyed (R$/km²)		9,06 – 108,18	4.336,18

*These values represent only the spend in the year of purchase of the UAV.

Where the amount spent annually on maintaining an ASA equivalent to multiplying the value of the monthly salary stated by the SSM (R$ 1,014.00) for 12 months plus 1, equivalent to the thirteenth salary.

As the PMCD has 210 ASAs which held four daily visits cycles per year totaling 638.32 square kilometers, and remembering that the area inspected by cycle follows the administrative division, ie 159.58 square kilometers, the area inspected by an ASA per year is approximately 3.04 square kilometers.

Another factor to consider is outsourcing, leasing an UAV instead of acquiring it, as occurred in other Brazilian cities. In all cities, the lease was in the form of daily payment at a cost of R$ 1,000.00 per day.

When compared to the cost of acquisition of other UAVs outsourcing option requires a greater investment which makes it economically less attractive than the acquisition especially when the flight configuration is for flights from lower altitude. Therefore, it was decided to discard this option.

Based on the costs in a year with the acquisition of a UAV and the

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maintenance or hiring an ASA. It was reached the costs per square kilometer according to Tables 2 and 3 have shown. With a capacity to annually inspect 55.55 to 1326.60 square kilometers which is equivalent to 18-436 ASAs the UAV has shown economically attractive since even in its higher cost per flight configuration the UAV is about 20 times more economical than an ASA annually.

Importantly, In 2015 scenario the UAV does not have a value that represents your annual cost after their acquisition because it expenses will be related only to maintenance which depends on the budget delivered by the contractor and spare parts if damaged.

So the payback presented in this paper is based on the logic of simple payback. Thus only considers the amount invested in the acquisition of UAVs and agent training to be responsible for flying it. The payback is estimated by the savings that it will provide during the time of its use. The reach area was the most important factor to compare the use of UAV versus the work of ASA.

Tables 4 and 5 show the payback times for the configuration of a daily flight, with the lowest and highest cost per square kilometer respectively.

Table 4: Payback lower cost per square kilometer to a daily flight

	Period	Number of daily flights	UAV	ASA
Investiment (R$)	1 year	1	9.719,00	13.182,00
Training (R$)			2.299,00	-
km² surveyed			55,55	3,04
cost of km² (R$/Km²)			216,35	4.336,18
Difference in costs of Km² (R$)			4.119,83	
VANT x ASA relation			1 VANT = 19 ASAs	
Savings (R$)			82.396,69	
Payback time			36 working days	53 days

Table 5: Payback higher cost per square kilometer to a daily flight

	Period	Number of daily flights	UAV	ASA

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	Period	Number of daily flights	VANT	ASA
Investiment (R$)			9.719,00	13.182,00
Training (R$)			2.299,00	-
km² surveyed			663,30	3,04
cost of km² (R$/Km²)	1 year	1	18,12	4.336,18
Difference in costs of Km² (R$)			4.318,06	
Relação VANT x ASA			1 VANT = 19 ASAs	
Savings (R$)			86.361,23	
Payback time			35 working days	51days

Tables 6 and 7 show the values obtained and the payback time for the configuration of two daily flight, with the lowest and highest cost per square kilometer respectively.

Table 6: Payback lower cost per square kilometer to 2 daily flight

	Period	Number of daily flights	VANT	ASA
Investiment (R$)			9.719,00	13.182,00
Training (R$)			2.299,00	-
km² surveyed			111,09	3,04
cost of km² (R$/Km²)	1 year	2	108,18	4.336,18
Difference in costs of Km² (R$)			4.228,00	
VANT x ASA relation			1 VANT = 19 ASAs	
Savings (R$)			84.559,95	
Payback time			36 working days	52 days

Table 7: Payback higher cost per square kilometer to 2 daily flight

	Period	Number of daily flights	VANT	ASA
Investiment (R$)			9.719,00	13.182,00
Training (R$)			2.299,00	-
km² surveyed			1326,60	3,04
cost of km² (R$/Km²)	1 year	2	9,06	4.336,18
Difference in costs of Km² (R$)			4.327,12	
VANT x ASA relation			1 VANT = 19 ASAs	

Savings (R$)			86.542,42	
Payback time			35 working days	51 days

Analyzing the values found it is possible to notice that all payback times are closer regardless of the flight configuration. Thus, through an investment of R$ 12,018.00 with an annual savings between R$ 82,396.69 to R$ 86,542.42 the payback time of the acquisition of DJI Phantom 3 Advanced and training of an operator is approximately 36 working days or 52 consecutive day which is almost two months.

This result proves that the acquisition of a UAV is feasible since getting a UAV of the selected model along with the training of 1 ASA is in square kilometers surveyed annually equivalent to 19 ASAs.

6. FINAL REMARKS

According to the goals set for this study an evaluation of dengue control logistics in Maringa was accomplished and through this it was understood as the dengue control process runs. From this understanding the execution of an operational process of mapping was possible through the monitoring agents in the field since this mapping was not defined by the SSM before.

Accompaniments performed along to field agents allow to identify areas of difficult access as well as sites that offer risk the health of the agents and thereby identifying possible uses of the UAV as a support tool for agents in dengue control.

After studies on the use of UAVs in dengue control, it was studied which the relevant operational constraints facing the legal aspects of the use of UAVs in civil airspace, and from these selected models of UAV that suited the purpose of use as an aid tool in the search for potential outbreaks of breeding sites of dengue mosquitoes transmitter.

Finally, an economic analysis regarding the use of UAVs in dengue control process was conducted by comparing the costs per square kilometer inspected annually by ASAs and UAV. It was concluded that because of its low cost per square kilometer surveyed the acquisition of a UAV with the training of an ASA is economically attractive which means that the acquisition of a UAV as the ASA aid

tool in dengue control in Maringa is feasible.

Despite being a modern theme, the use of UAVs, other than for recreational purposes or military, is not explored by the scientific community. In addition of the scarce literature, it was only in September 2015, the Administrator sent public hearing regulations for the use of UAVs in Brazilian civil airspace. Another difficulty faced was finding a way to compare UAVs and ASAs, whereas for this study, was not available for one UAV testing.

To evaluate the benefits of using a UAV as a tool to help dengue control, it is important to conduct practical tests in order to collect data about the improvements that this can bring. From these tests, it is possible to search through virtual simulations, improved methods logistics for the current process dengue control in Maringa become more efficient, and thus bringing social and economic benefits by reducing the cost of combating the disease, to the municipality.

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