Metadata of the chapter that will be visualized in SpringerLink

Book Title	Applied Computer Sciences in Engineering	
Series Title		
Chapter Title	Design and Implementation of a Laboratory Sample Collection System Using an Unmanned Aerial Vehicle (UAV)	
Copyright Year	2018	
Copyright HolderName	Springer Nature Switzerland AG	
Corresponding Author	Family Name	**Krejci Garzon**
	Particle	
	Given Name	**Edgar**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	Corporación Unificada Nacional de Educación Superior CUN
	Address	Bogotá, Colombia
	Email	edgar_krejci@cun.edu.co
Author	Family Name	**Diaz Gutiérrez**
	Particle	
	Given Name	**Yesid**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	Corporación Unificada Nacional de Educación Superior CUN
	Address	Bogotá, Colombia
	Email	yesid_Diaz@cun.edu.co
Author	Family Name	**Salgado Alba**
	Particle	
	Given Name	**Manuel Alberto**
	Prefix	
	Suffix	
	Role	
	Division	
	Organization	Corporación Unificada Nacional de Educación Superior CUN
	Address	Bogotá, Colombia
	Email	manuel_Salgado@cun.edu.co
Author	Family Name	**Celis Florez**
	Particle	
	Given Name	**Fernando Agusto**
	Prefix	
	Suffix	

	Role	
	Division	
	Organization	Corporación Unificada Nacional de Educación Superior CUN
	Address	Bogotá, Colombia
	Email	fernando.Celis@cun.edu.co

Abstract	The use of innovative technology is available to apply in many ways and in different fields of knowledge, the Horus research group, has focused its efforts implementing solutions, integrating unmanned aerial vehicles known as drones in different areas. The use of drones to perform different tasks is not new, but from the point of view of the Horus research group, it was established that this technology can be applied to analyze different water systems with possible contamination quickly and efficiently, otherwise to collect samples in places where access is difficult it would take more time and money in the process. For that, a system was designed using a drone assembled by the research group with a pumping system, to collect samples for further analysis in laboratory in a way that they are not contaminated using technical standards according to the regulations of the area where they are collect.

Keywords (separated by '-')	Drone - Samples - Protocol - UAV

Design and Implementation of a Laboratory Sample Collection System Using an Unmanned Aerial Vehicle (UAV)

Edgar Krejci Garzon(✉), Yesid Diaz Gutiérrez, Manuel Alberto Salgado Alba, and Fernando Agusto Celis Florez

Corporación Unificada Nacional de Educación Superior CUN, Bogotá, Colombia
{edgar_krejci,yesid_Diaz,manuel_Salgado,fernando.Celis}@cun.edu.co

Abstract. The use of innovative technology is available to apply in many ways and in different fields of knowledge, the Horus research group, has focused its efforts implementing solutions, integrating unmanned aerial vehicles known as drones in different areas. The use of drones to perform different tasks is not new, but from the point of view of the Horus research group, it was established that this technology can be applied to analyze different water systems with possible contamination quickly and efficiently, otherwise to collect samples in places where access is difficult it would take more time and money in the process. For that, a system was designed using a drone assembled by the research group with a pumping system, to collect samples for further analysis in laboratory in a way that they are not contaminated using technical standards according to the regulations of the area where they are collect.

Keywords: Drone · Samples · Protocol · UAV

1 Introduction

The use of drones in our society every day is very common, in commercial applications have the potential to dramatically alter several industries, and, in the process, change our attitudes and behaviors and impact our daily lives. The proponents of late modern war argue that it has become surgical, sensitive and scrupulous, and remotely operated Unmanned Aerial Vehicles or 'drones' have become diagnostic instruments in contemporary debates over the conjunction of virtual and 'virtuous' war [1] the implementation of these equipment managed and piloted by certified professionals are essential to solve different problems, where access by land is very difficult, the group research found a problem of water pollution generated in a stream that is located in south of Bogota city called Chiguaza, [2] it causing serious health problems to the student community of a public school, for this reason it is vital to take samples of this water

J. C. Figueroa-García et al. (Eds.): WEA 2018, CCIS 916, pp. 1–12, 2018.
https://doi.org/10.1007/978-3-030-00353-1_14

source to maintain control and prevent pollution affecting the students of the sector.

According to Alenna Otto Many industries can potentially benefit from pilotless technology because it can reduce labor cost. Drones can operate in dangerous environments that would be inaccessible to humans. Furthermore, pilotless technology lowers the weight of theaircraft, and thus its energy consumption, by making the cockpit and environmental systems, which provide air supply, thermalcontrol, and cabin pressurization, unnecessary. Drones do not require roads and can, thus, access locations that are difficult to reach by roads [3].

The project provides information in two areas, first the collection of samples in sterile bottles used according to technical standards of laboratory, during transport recommended refrigeration at 4°C and protection of the Light, especially if it is suspected that the water is contaminated with pathogenic organisms. It is necessary when refrigerating the samples take precautions and necessary measures to prevent any contamination coming from the melted ice [4], so that in a time no more than six hours those samples arrive at the laboratory and could be analyzed, with the purpose of determining the level of contamination existing, After using a web application the data can be sent quickly to the competent authorities so that they take the pertinent actions and prevent this water source from contamination and affect the community that is close to this water tributary.

It is important to highlight that the project intends to provide information for the analysis of the level of toxicity of this water source, where the amount of foam, level of chemical elements harmful to human health, and to be able to give early warnings to the relevant authorities, see Fig. 1.

Fig. 1. Evidence, Chiguaza stream and its level of contamination present in the water source.

The stream descends from the southeastern hills to flow to the river Tunjuelito the hand of man has contributed to the pollution of this water source, adding to it industrial waters, chemical pollution, lead residues, mercury, copper, sand, gravel and other materials coming from the exploitation of subsoil [5].

Along the stream it can be observed that it crosses the Colombia viva school and the Molinos sports center, where the people of this community are affected by bad smells, in addition to respiratory annoyances. Each time rainfall occurs and the flow of the stream increases, mosquito proliferation is generated, which requires constant monitoring and sampling of water in different places with difficult access, for which the use of a Drone it is vital to achieve this goal.

To make this type of sampling, it must be fixed different points in the water tributary to analyze which factors are contributing to regenerate pollutants up to the location point of the living district of Colombia. The Fig. 2 shows the location of this stream and its respective distance.

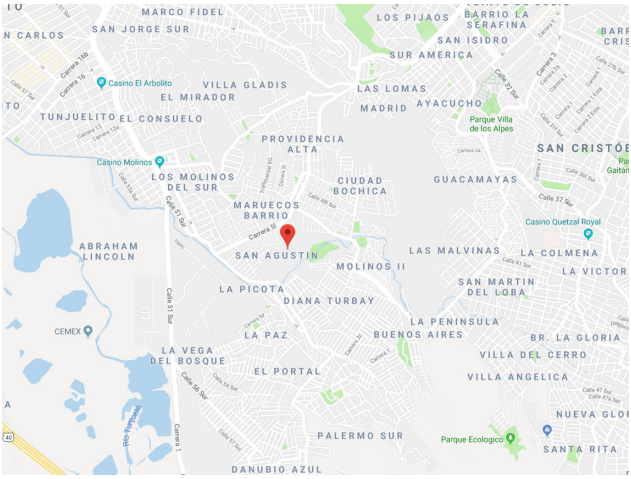

Fig. 2. Broken path Chiguaza stream source Google Maps, latitude = 4.5, longitude = −74

2 Use of Drones in the Field of Water Sampling

Because of its great versatility in access to bodies of water whose quality control represents some degree of difficulty, unmanned aerial vehicles called drones are a very useful tool during the sampling operation, as the first stage of the chain of custody of samples for the quality control of a body of water. However, the nature of the equipment required for sampling and the drone's load capacity limit the hydrological scenario of operation and, consequently, the type of sampling that can be carried out through said equipment.

Hydrological monitoring is fundamental for the knowledge of the water resource based on which the decisions for its administration and management are supported, according to the criteria of the National Plan for the Integral Management of the Water Resource - PNGIRH. In this sense, the Institute of Hydrology, Meteorology and Environmental Studies, IDEAM, is in charge of establishing the protocols and procedures for quality monitoring of the national water resource as one of its scientist support functions to the Environmental Information System [6].

The IDEAM has made available a Protocol for the Monitoring and Monitoring of Water based on whose types of sampling it is possible to establish the use and potential of a drone for taking water samples from certain water bodies [7]. In this sense, the utility of the equipment is given to the extent that the sample of water taken through the drone represents the quality of the water body from which it comes, as a basis for the validity in the measurement of physicochemical or microbiological parameters whose analysis obtains information to infer possible affectations of natural or anthropic origin on the hydric body. Checking the characteristics of stationary flight and the carrying capacity of a drone, it is feasible to use it for the following types of sampling in accordance with the Protocol for Water Monitoring and Monitoring:

Punctual sample. It is possible to make discrete point intakes of both surface and depth in stationary surface water bodies whose composition does not vary with time, as well as in quasi-stationary surface water bodies whose composition may vary slightly with time, but which are likely to be stabilized or homogenized for a period of 24 h or less through a treatment.

Point sampling allows to obtain water quality status characterizations at a certain geographical point and time, based on which it is possible to configure water body quality histories. Integrated sampling It is possible to integrate several point samples obtained at a geographical point and at a specific moment, but at different depths in the same water column.

Sequential composite sample. It is also possible to obtain a water sample that represents an average quality in a specific period of time, based on the mixture of constant and continuous samples obtained by pumping, or of the mixture of equal volumes of water collected at regular intervals.

Although composite sampling is economical because it requires less samples, it compromises the level of detection of variability of the measurement parameters during the sampling time.

Basic principles for measuring through a drone. The usefulness of an unmanned aerial vehicle (drone) in the field of water analysis from water bodies is only sustainable insofar as the analysis of the samples obtained with this equipment permit measurement values of physicochemical parameters and microbiological statistics equivalent to the results of the analysis of samples taken in identical geographic point conditions and time period by certified personnel in water sampling, in accordance with the Protocol for Water Monitoring and Monitoring.

The validity of the statistical process of homologation of the results of analysis of samples obtained by the drone in comparison with the results obtained by certified personnel, is determined by factors such as the impossibility of completely eliminating errors (spurious and systematic) of measurement in water bodies, which by their nature present considerable fluctuations in the values of the parameters measured in a given period of time, which introduces uncertainty in the calculation of dispersion measures that are the basis for the calculation of probabilities. This implies an estimation of the uncertainty based on the study of the sources of error associated with the measurement when the point samples are independent of each other. However, hydrological observations are not usually independent random variables.

3 Description of the Problem

The procedures for taking water samples require a strict protocol where the sample that is taken must not have any type of contaminant, before and after the procedure, to make these samples requires certified and trained personnel to carry out the process, the times they are critical and to have reliable samples several shots must be taken at different points, that is why it needs to have a system that is easy to use and reliable so that the samples are taken as much as possible on the same day, since a water affluent to be in constant movement the samples tend to change constantly, a typical example is one of the most polluted rivers in the world, the Bogota river one of the most studied, for the process of data collection, is an extensive process and expensive, so the main problem is the delay in these samples and the cost that the process has. The Fig. 3 shows the factor of affectation due to organic contamination of the Bogota River, that

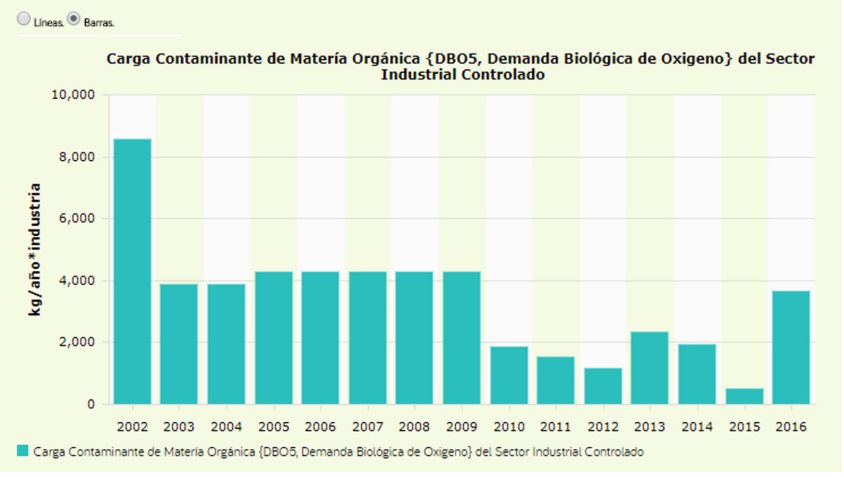

Fig. 3. Polluting load river Bogotá (National observatory source of Bogota).

is why the importance of having more efficient systems of sample collection for faster and more effective results.

4 Design Model Sample Collector

4.1 Unmanned Aerial Vehicle to Be Used

The equipment that was used to make the samples is a DJI F450 kit see Fig. 4, DJI is known mainly for its high-end drones line but it also has a very economical kit that serves to implement prototypes, to mount sensors, the chassis allows mounting all the necessary electronics, autopilot, GPS, brushless motors, [8] which was assembled by the Horus research group, this chassis and equipment has the advantage that can be modified and work to implement any electronic device, to perform Actual tests of the water sample collection device [9].

The great advantage of this equipment is that it serves as the basis for calculating the efficiency of the water collection system, depending on the amount of liquid that needs to be collected, we can implement another drone that supports more payload.

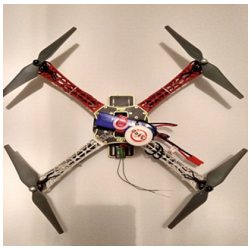

Fig. 4. Drone F450 assembled by students of the HORUS research group.

Table 1. Main technical characteristics of the drone

	Description	Value	Unit
Wto	Weight	12,054	Kg
S	Alar surface	0,749	m^2
Pto	Power	3147	Watt
Lb	Fuselage length	1400	mm

4.2 Characteristics of the Drone

The preliminary calculation of the size is obtained from the study of similar aircraft, and adapting the calculation theory of manned aircraft to the UAV (batteries fixed weight, without crew without life maintenance systems, etc. ...), the weight, and fuselage length, Table 1. And the design point that satisfies the most restrictive actions of the UAV is defined [10].

4.3 Assembly System Sample Collector with Arduino Nano and Mini Brushless Water Pump for DIY Agriculture Drone Spray Gimbal 5 L 10L

According to the advantages we have with the drone, we can assemble a device to operate by radio frequency the mini pump remotely, see Fig. 5. The technical characteristics of the mini pump are in Table 2, using an Arduino nano device to activate the pump. performs programming, to activate the mini pump remotely using a relay to activate the entire device, making previous calculations with the pump is activated 30 s accurate time to fill a sterile collector jar of water samples of 500 Ml.

Table 2. Mini pump technical characteristics

Name: Agricultural drone brushless Water Pump spray/white
Model: 12-420
Weight: 294g
Power: 16W
Operating voltage: 12V
Maximum current: 1.3A
Maximum pressure: 0.45Mpa
Flow: 3L / min
Agricultural drone model:5L/10L
Size: 110 * 90 * 65mm

4.4 Implementation Used to Send a Radio Frequency Signal to the FS-IA6 Device Keeping Un Mind the Radio Electric Spectrum Used in Aeronautics

The FS-IA6 module is a signal receiving device that operates the whole system so that the drone works without problem, using the radio control of the brand FlySky FS-I6 to 2.4 GHz according to the publication drones cheap “If we want Therefore, we must seek a more powerful control which will surely have a greater value, another option is also to look for a remote control that works in the standard frequency of 2.4 GHz, the controls normally used have lower frequencies, can achieve greater range and greater penetration through obstacles. These controls use frequencies in the UHF band, however they are being banned”.

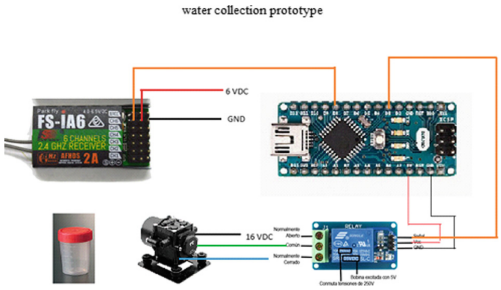

Fig. 5. Receiver connections FS-IA6, to the Arduino nano module, with a relay for activating the pump remotely.

To activate the sample collection system, the available channel 6 is used to activate the sample collection device that is mounted on the drone, for which calculations were made, keeping in mind the current regulations, and the efficiency of the system was determined using the 2.4 GHz frequency.

Using the following equation, which measures the power loss in the free space, it is determined that the most efficient means of transmission with the remote system to activate the collector device is by radio waves.

$$PEA(dB) = 20\log 10(d) + 20\log 10(f) + K$$

The formula is interpreted in the following way, the Loss in Free Space is proportional to the square of the distance and also proportional to the square of the frequency [11].

4.5 Process Model 1

The system works in an efficient way for the collection of samples, so that it is not contaminated by external factors while the drone collects them, see Fig. 6; the phases of the process are:

1. Flight Route is programmed.
2. The drone pilot uses Channel 9 of the radio control to activate the device when it reaches the fixed point on the route.
3. The sample is collected according to the calculation of time to fill the container where the sample is stored.
4. The drone returns to the starting point.
5. The technician collects the samples in the container with all the rules to avoid contaminating them.
6. They are sent to the laboratory to process the sample.

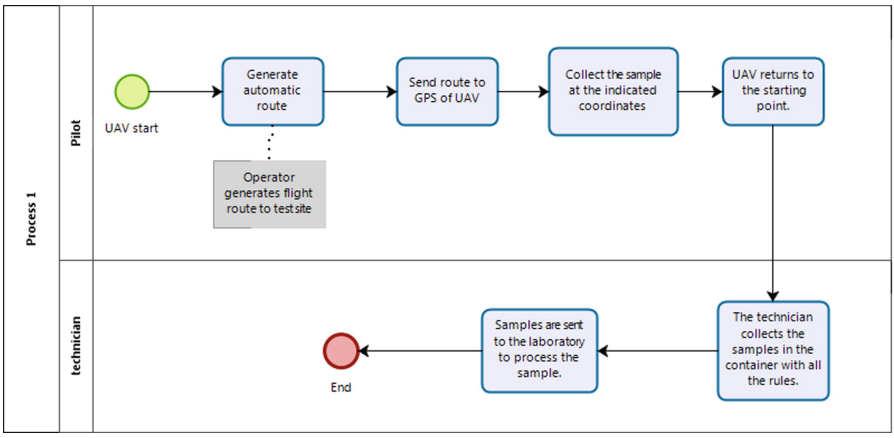

Fig. 6. Process model 1 implementation.

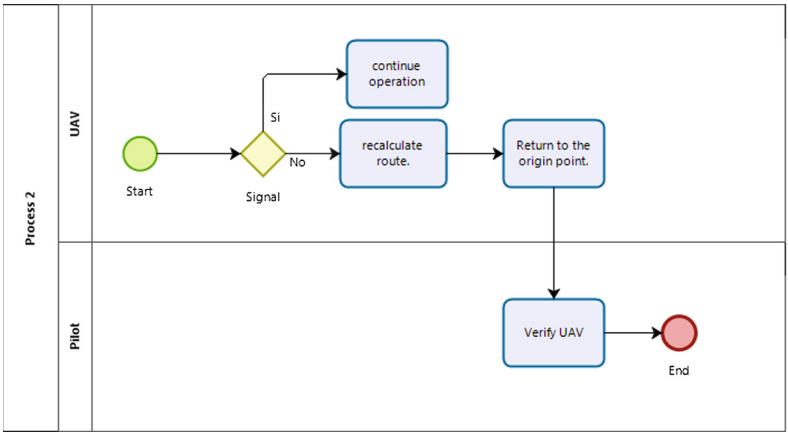

Fig. 7. Process model 2 implementation.

4.6 Process Model 2

In case of loss of signal by the operator, the automatic system of the drone detects that the signal, with the radio control was lost, cancels the mission and returns to the starting point, see Fig. 7.

1. Flight route schedule.
2. It is detected that the signal was lost with the drone.
3. The drone detects communication loss.
4. Automatically the drone return to the starting point.

5 Implementation Code for Arduino Nano

For the development of the platform, an Arduino nano device was used, which is programmed with the exact times for the pump to activate properly and collect the amount of 500 Ml for the sample.

```
int entrada=1;
int bomba=3;
void setup() {
pinMode(entrada,INPUT);
pinMode(bomba,OUTPUT);
}


void loop() {
if (digitalRead(entrada)>0){
digitalWrite(bomba,HIGH);
delay(30000);
digitalWrite(bomba,LOW);
}
}
```

6 Results

Taking reference to the Chiguaza stream, we proceed to collect the samples using the system, where we proceed according to the technical parameters for sampling.

If it is possible to collect, the 500 Ml of the water system is labeled and stored taking into account the standards for sampling. At the same time a specialized technician collects other samples with the standard procedure used, to be later compared in a laboratory.

It is determined that the efficiency and rapidity in taking samples improves times and, most importantly, being able to collect samples in places where access is very difficult, using drones and the pump system streamlines processes.

According to the data collected, it is evident that, with the collection system, the times for sampling are better than the time used by an environmental technician.

7 Conclusions and Recommendations

The use of unmanned aerial vehicles, facilitates work in places where data collection is very difficult for human personnel, the design of devices using hardware components for the Arduino platform, is very practical and economical for multiple uses, not only for the case that this article deals with if not for different ideas that can help the collection of data in an effective, safe and fast way.

In this sense it is important to consider the current regulation for the use of unmanned aerial vehicles, in the case of Colombia this regulation limits the use of these vehicles, in certain areas of the country, especially in the cities, that is why the solutions are. They must be routed in areas where this regulation allows the use of this technology. In another countries for example Europe the regulation says in a Law Library of Congress text titled Regulation of Drones surveys the rules that apply to the operation of civilian drones in twelve countries, as well as the European Union. The report includes individual country studies on Australia, Canada, China, France, Germany, Israel, Japan, New Zealand, Poland, South Africa, Sweden, Ukraine, and the United Kingdom. It also contains a comparative summary that provides information about the International Civil Aviation Organization's 2011 circular titled Unmanned Aircraft Systems (UAS) (CIR328). The report notes the criteria selected by the surveyed countries and by the EU for implementing a number of operational requirements. Such criteria often include the weight and/or type of use of drones [12].

The research work resulting from this article leads us to make the comparisons of the samples taken by the Drone and by the environmental technician, in this process some data will come out, which will show us if the system does not contaminate the samples taken, and be able to have reliable results to be processed in software platforms.

References

1. Gregory, D.: From a view to a kill: drones and late modern war. Theory Cult. Soc. **28**(7–8), 188–215 (2011). https://doi.org/10.1177/0263276411423027 AQ5
2. María, A., Velásquez, T.: Lineamientos ambientales para la recuperación de la quebrada Chiguaza en su recorrido por la localidad Rafael Uribe Uribe Bogotá. Universidad de Bogotá Jorge Tadeo Lozano (UJTL), Bogotá D.C. (2010) AQ6
3. Otto, A., Agatz, N., Campbell, J., Golden, B., Pesch, E.: Optimization approaches for civil applications of unmanned aerial vehicles (UAVs) or aerial drones: a survey. Networks (2018). https://doi.org/10.1002/net.21818
4. Varón, J.E.: Manual de Instrucciones para la toma, Preservacion y transporte de muestras de agua de consumo humano para muestras de laboratorio, Bogota (2011)
5. Periódico El tiempo, p. e., www.eltiempo.com. Recuperado el 14 de 02 de 2018, de. http://www.eltiempo.com/archivo/documento/MAM-50381. Accessed 21 Feb 1994
6. Guía de Prácticas Hidrológicas, Volumen I, Hidrología - De la medición a la información hidrológica, OMM-N 168, Capítulo 7, p I, 7–6. Métodos de Observación
7. Protocolo para el Monitoreo y Seguimiento del Agua, Instituto de Hidrología, Meteorología y Estudios Ambientales - IDEAM 2007, Capitulos 2 y 3
8. Santana, E.: www.xdrones.es. http://www.xdrones.es/kit-drone/. Accessed 15 Feb 2018
9. Futuro, M.D.: Tomas muestras Hidricas quebrada Chiguaza. Bogota. Obtenido de. https://www.youtube.com/watch?v=3oFlQuQm85E. Accessed 22 June 2017
10. GRUPO UAx UPV. http://uaxupv.blogs.upv.es/diseno-y-fabricacion-de-un-uav-de-diez-kilogramos-de-carga-paga/. Accessed 08 Feb 2018

11. Meléndez, J.E.: http://repositorio.urp.edu.pe. Recuperado el 23 de 3 de 2018, de http://repositorio.urp.edu.pe/bitstream/handle/urp/77/ojeda_je.pdf?sequence=1. Accessed 03 Feb 2008
12. Levush, R.: The Law Library of Congress (2016)

Author Queries

Chapter 14

Query Refs.	Details Required	Author's response
AQ1	This is to inform you that corresponding author has been identified as per the information available in the Copyright form.	
AQ2	We have abbreviated the name "Edgar Krejci Garzon" to "E. Krejci Garzon," in the running head appearing on top of Page 2. Please check and confirm.	
AQ3	Please check and confirm if the authors Given and Family names have been correctly identified.	
AQ4	Per Springer style, both city and country names must be present in the affiliations. Accordingly, we have inserted the city 'Bogotá' name in affiliation. Please check and confirm if the inserted city name is correct. If not, please provide us with the correct city name.	
AQ5	Please check and confirm if the inserted details are correct in Ref. [1].	
AQ6	Please check the edit made in the Ref. [2] is correct.	