Drones for Inspection and Control in Industry 4.0

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***Abstract*—This paper presents a brief idea of drones, their technology and can be used for different purposes. New technologies such as machine learning, Artificial Intelligence (AI), the Internet of Things (IoT) and drones are transforming the workforce. Major aim of this project is for surveillance, inspection. The most important feature of the drone is the transmission of images and video in real time (FPV). They highlighted the safety areas, as risky tasks such as thermometry and specific tool maintenance can now be performed without exposing workers. Finally, more than 40 cases of use have been validated, mainly for the security of assets, for the areas of exploration, projects, engineering, construction, planning and logistics, maintenance, quality and environment, production and above all, personnel safety.**

Keywords— surveillance drone, FPV drone, energy efficient drone, less noise, Industry 4.0.

I. INTRODUCTION

The 2016 was a drone's year, a true revolution occurred in terms of the hardware and software used in both the manufacturing process and in controlling drones. This has made these devices easier to maneuver, able to fly more, be safer and able to obtain video footage and high-resolution photos at a professional level. In recent research it is clearly observed that drones are about to create a revolution in human life and industry. The most important aspect is that it can be used for effective surveillance at places where human being can't reach. To reduce the cost of the drones, Low cost avionics System Prototypes are made. It makes the structure light as well as strong.

The paper deals with a drone which has its location being directed by GPS giving its exact location. The most important aspect of this paper deals with the detection of unidentified obstacles which tend to create disturbance in the normal environment. Capturing and reporting all minute details as the camera associated with it moves as per our direction. Using of GPS for automatic mission planning, the stabilization of the drone for proper surveillance and the FPV part are the advantageous where we can control it through the remote.

In our capture of models and alternatives for our company or industry we are going to raise a comparative of certain models of Drones with certain characteristics and using TOPSIS we will be able to arrive at our ideal solution.

The TOPSIS method has been selected because it is one of the most widespread and applied methods of operational research in the industry. It was developed by Hwang and Yoon (Technique for Order Preference by Similarity to Ideal Solution, 1995) based on the concept that it is desirable for a given alternative to be located at the shortest distance from an ideal positive solution and at the longest distance from an ideal negative solution.

The Ministry of Environment and Water in Dubai has started using drones for monitoring the work of crushers and quarries. Nokia [2] plans to use flying drones as a public safety system for cities. PrecisionHawk [3] has been offering remote sensing and data processing services using drones for various applications such as infrastructure monitoring and search/rescue.

Recent advances in sensor and embedded device technologies are also pushing the pervasive data acquisition and processing capabilities in different city infrastructures such as roads, traffic signals, sidewalks and bridges to monitor.

II. MODELS OF THE INTERFACE

Each of the screen will have relationship with the different module of the intelligent dashboard.

The next window will show the first module called "Agregar" in this module you can add an alternative by the name of the product and 5 of their characteristics included the price, this is with the purpose to add the most characteristics for compare the alternatives.

The variables of each *Self.Entry* is declared as *StringVar()*. When you introduce the information they go to the DataBase.

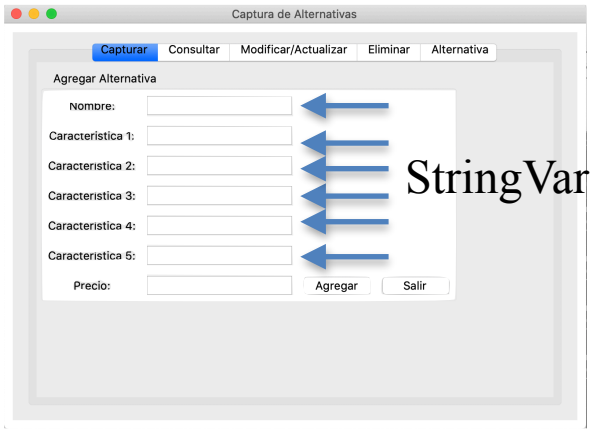


Figure 1 Source own elaboration.

In the second module called "Consultar" you can view all the alternatives saved in the BD separated by categories. If you need to check any data these module are the indicated.

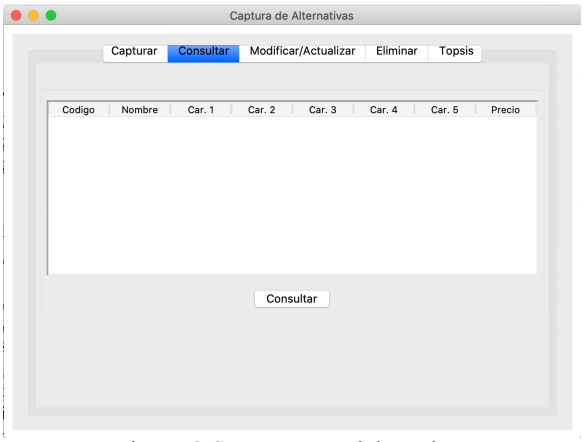


Figure 2 Source own elaboration.

The third module is called “Modificar/Actualizar” in this module you can modify or update the attributes of you alternatives only if you need to make some corrections before the program create the TOPSIS method. The correct form to use this module you need to write the code generated when you add any alternative on the BD, when you write the code all the fields gonna be full with the information.

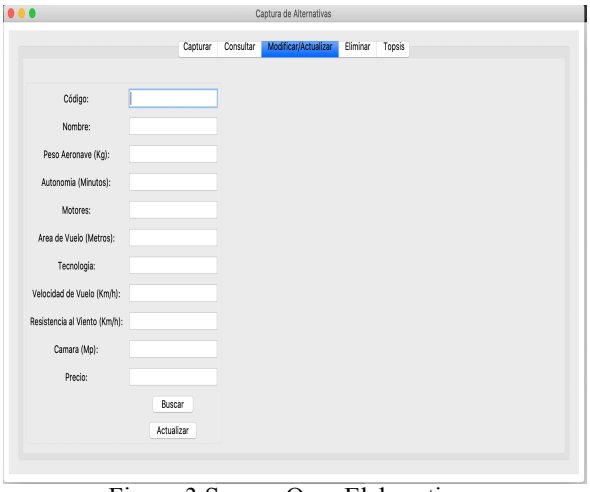


Figure 3 Source Own Elaboration

Fourth module is very simple due you only need to write the code of the alternative to eliminate by 1. Be careful of digit the correct code.

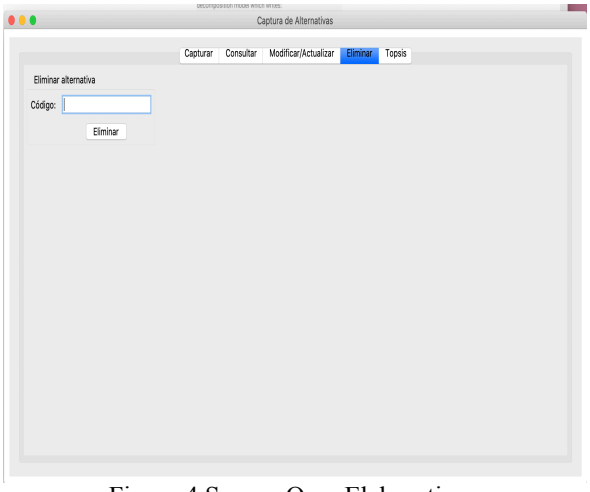


Figure 4 Source Own Elaboration

III. DRONE APPLICATIONS

Drones can be used for many applications but we will focus mainly on those in Industry 4.0. We will analyze Thermography, Photogrammetry, Scanning (point cloud), Inspection of power lines, Inspection of infrastructure, Inspection of wind turbines, Inspection of chimneys and gas leaks, Inspection of pipelines, tanks and reservoirs, Inspection of oil platforms, Energy efficiency.

The objective of the use of this new technology is to facilitate the work of companies in the industrial sector as well as to minimize expenses and risks, reducing the use of personnel, the time of execution of the work and as a consequence the cost.

Thermography

Thermography is a technique that allows calculating and determining the surface temperature of objects at a distance, without the need for physical contact with the object being studied. Thermography allows the capture of infrared radiation of the electromagnetic spectrum, using thermographic or thermovision cameras. We can carry out both qualitative (by comparing temperatures) and quantitative (by giving numerical values) inspections, incorporating qualified thermographs in the template.

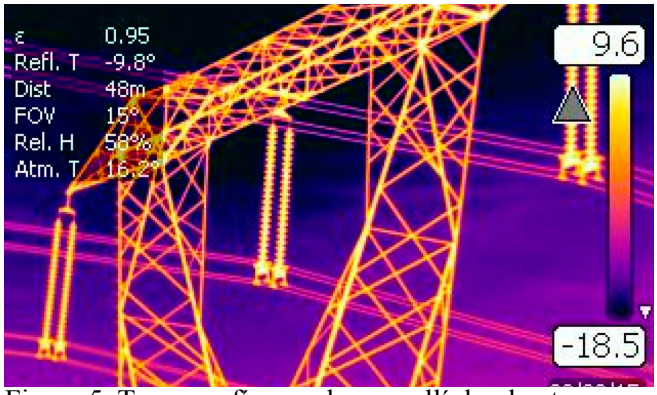


Figure 5 Termografía con drones, allí donde otros no llegan.

Photogrammetry

Photogrammetry is a technique to determine the geometric properties of objects and spatial situations from photographic images by obtaining 3D models and/or maps from the generated point clouds. With it and with our drones equipped with GPS, the georeferencing of the objects and points scanned is obtained. In the same way, by exchanging different cameras we can generate thermal or visible spectrum maps.

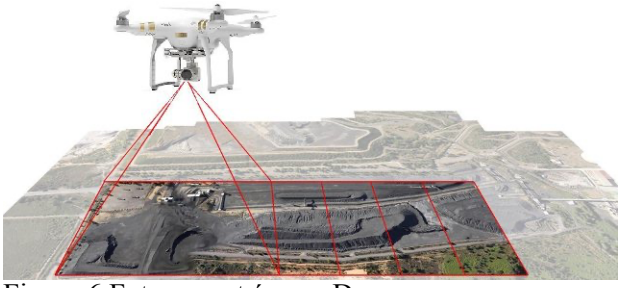


Figure 6 Fotogrametría con Drones

Scanning (point cloud)

By combining traditional scanning techniques, such as three-dimensional laser scanners, and the point clouds generated by our drones, we obtain a data file with a totally complete point cloud, avoiding blind spots in the facilities.

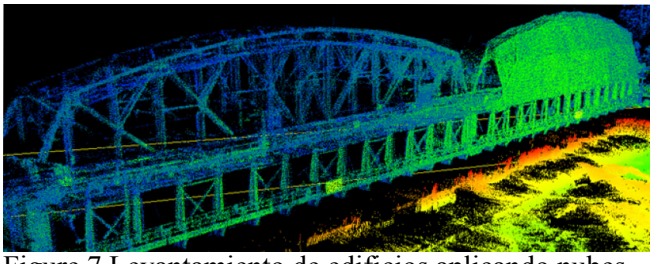


Figure 7 Levantamiento de edificios aplicando nubes de puntos

Inspection of power lines

Exhaustive visual and thermographic inspection of the electric, low and high voltage lines. The drones prevent workers from climbing the tower and traveling long distances for the execution of our projects, delivering higher quality data by not running the risk of taking information. Inspections are speeded up and power cuts are avoided, executing this, right at the time of the execution of the work.

Figure 8 Expansión de la Inspección de las Líneas Eléctricas con la Tecnología de Drones

Infrastructure inspection

Safety inspection of buildings, structures and cranes, by means of a periodic review. It allows us to detect and measure corrosion, deformation and cracks. Traditional methods are often risky, slow, expensive and involve closing lanes, using truck cranes, walkways, etc.

Figure 9 Inspección y auscultación de infraestructuras

Inspection of wind turbines

Inspection of shovels, main hub and blades. Inspection of mast, hub and blades in both visual and thermal spectrum.

Figure 10 Eólica y energías renovables: nuevo sistema de inspección de palas de aerogeneradores

Inspection of chimneys and exhaust gases

Visual inspection for corrosion, deformation, surface treatment and possible cracks. Detect hot spots in an exhaust stack and cold spots from gas leaks. It is not necessary to stop production to carry out the inspection.

Figure 11 Altura minima de chimeneas industriales

Inspection of oil platforms

Visual inspection for corrosion, deformation, surface treatment and possible cracks. Inspection of structures at great heights and areas close to contact with the sea.

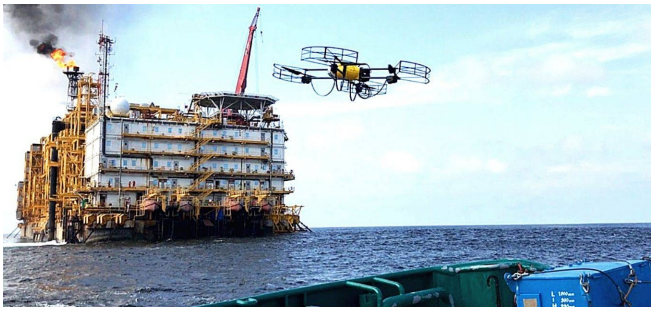
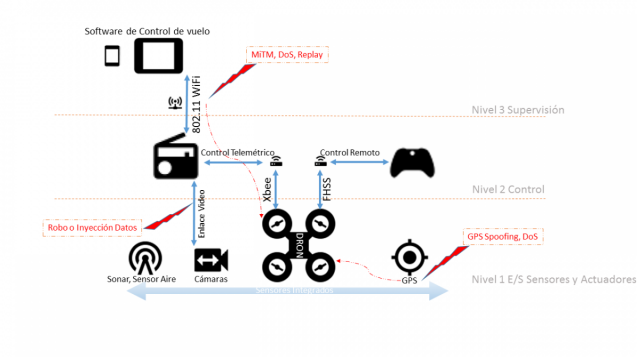


Figure 12 Plataformas petrolíferas

But before we go into detail, let's see how a drone works



How it can be shown in the image we see that the drone can be operated in different ways, remotely with a control or with the application for mobile devices.

The only disadvantage that the drones have, is the WIFI connectivity, they need to have a very good antenna to not have interference when receiving images or live video.

Here is a graph showing the drone market by sector

Chart 1: Drone Market by Sector

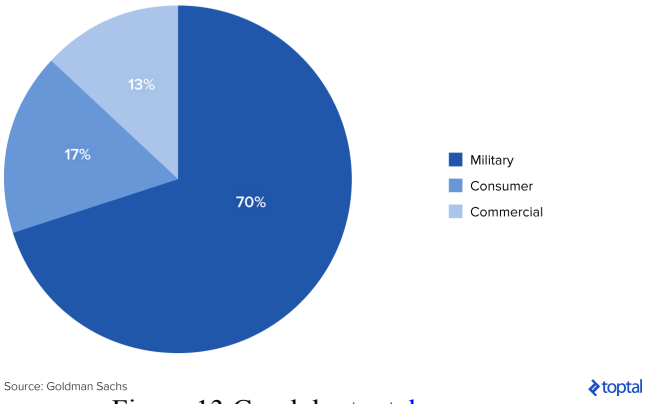


Figure 13 Graph by toptal.com

According to Gartner market research, the market size for commercial drones in 2016 was 2.8 billion with only 110 billion units sold. In 2017, it is estimated that commercial drone sales will grow by about 60% to 170,000. While personal drones dominate unit sales in 94% of the market, they comprise only 40% of the market's revenue share. Commercial drones account for only 6% of the market but their price tags of around $100,000 are projected to account for 60% of the industry's revenue.

Qualcomm Ventures	3DR AIRMAP Flirtey RedZone Robotics SKYCATCH swift
GV	Airware SKYCATCH Hivemapper zipline
intel Capital	Airware PRECISIONHAWK YUNEEC

Table 1 Most Active Corporate Ventures in the Drone Industry

Qualcomm Ventures, the most active venture capitalist, making six investments to date in companies focused on mapping, pipeline inspection, delivery, 3D mapping, stand-alone solutions and business solutions Qualcomm also acquired Kmel Robotics to expand its cellular technologies within the drone operations, launching its own commercial robotics solutions.

Google Ventures, which has also been actively investing in long-distance delivery, commercial end-to-end solutions and 3D mapping. Google Ventures has developed 63 patents related to drones through various drone capabilities.

Intel Capital, which has invested in a complete end-to-end business solution, an analytics solution and a hardware company. They have also acquired two companies, including Ascending Technologies, which is developing "sense and avoid" algorithms, and MaVinci, which is developing flight planning software. These acquisitions and investments have helped Intel develop its own solutions for commercial drone applications.

IV. THE TOPSIS METHOD

In our application to use the topsis method we are going to break it down part by part.

Let's first select our alternatives and then separate them by attributes, giving a weight to each attribute.

Alternatives: These are the options which are to be evaluated for selection of the best.

Attributes: These will impact the selection of alternatives.

Weight: These estimates relative importance of attributes.

Atributo	Peso	Autonomia	Motores	Distancia	Tecnologia	Velocidad	Resistencia	Camara	Precio
Peso	5	8	4	8	7	4	8	7	6

Rating Scale 1 Not Important - 10 Very Important

Attribute	Weight	Rating Scale
Peso	5	1 None - 10 Very Important
Autonomia	8	1 None - 10 Very Important
Motores	4	1 None - 10 Very Important

Attribute	Weight	Rating Scale
Distancia	8	1 None - 10 Very Important
Tecnologia	7	1 None - 10 Very Important
Velocidad	4	1 None - 10 Very Important
Resistencia	8	1 None - 10 Very Important
Camara	7	1 None - 10 Very Important
Precio	6	1 None - 10 Very Important

Once we select our attributes and the weight of each of them we will proceed to the decision matrix for each of the alternatives.

When we have the ideal matrix we will use the topsis methodology. Technique for Order Preference by Similarity to Ideal Solution. TOPSIS selects the alternative that is the closest to the ideal solution and farthest from negative ideal solution.

In this Method two artificial alternatives are hypothesized:

Ideal Alternative: One which has the best attributes values.

Negative Ideal Alternative: One which has the worst attribute.

V. MOORE VS TOPSIS

The Multi-Objective Optimization by Radius Ratio Analysis (MOORA) method starts with the response matrix of the other alternatives and different criteria. It then constructs the decision matrix, which contains n rows representing the A1 alternatives,... ,An in the evaluation, and J+L the columns representing the criteria under evaluation (J quantitative criteria and L qualitative criteria). For this step we will obtain the final decision matrix (FDM) with the following formula.

$$MDF = [VO, VST]$$

$$= \begin{matrix} A^1 \\ A^2 \\ \vdots \\ A^n \end{matrix} \begin{bmatrix} x_1^1 & \cdots & x_j^1 & x_{j+1}^1 & \cdots & x_{j+L}^1 \\ x_1^2 & \cdots & x_j^2 & x_{j+1}^2 & \cdots & x_{j+L}^2 \\ \vdots & & & & & \\ x_1^n & \cdots & x_j^n & x_{j+1}^n & \cdots & x_{j+L}^n \end{bmatrix}$$

Where *Ai* represents the alternatives, for *i=1...n* , and *xji* represents the entries for alternative i with respect to criterion *j*.

Calculate the standardized decision matrix.

It is feasible that the qualification criteria are expressed in different units or scales of measurement; therefore, normalization is carried out, where each response xij is compared to a denominator, which is representative of all the alternatives involving the criterion.

$$|X_j| = \sqrt{\sum_{1}^{n} x_i^2}$$

Therefore, the normalization of each FDM input is carried out according to the equation.

$$Nx_{ij} = \frac{x_{ij}}{|X_j|}$$

Calculate the weighted standardized decision matrix.

Taking into account the different importance of the criteria, the *WNxij* normalized weighted scores are calculated with the equation

$$WNx_{ij} = w_i \cdot Nx_{ij}$$

Calculation of the contribution of each alternative.

The contribution of each alternative is obtained using the equation.

$$Ny_i = \sum_{i=1}^{g} Nx_i - \sum_{j=g+1}^{m} Nx_j$$

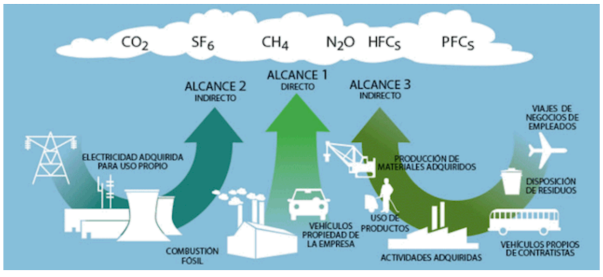
The previous steps were for the moora method, as a conclusion we can say that the most significant method is that of TOPSIS because taking into account the amount of variables it is difficult to obtain a concrete result with MOORA. This is because of the weighting of each attribute.

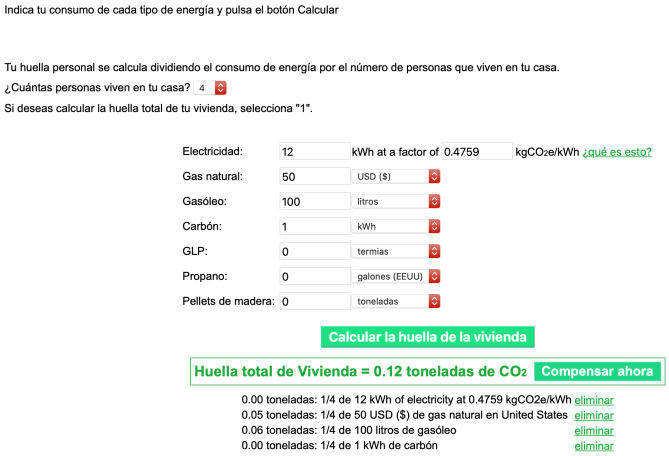
VI. CARBON FOOTPRINT

The dictionary says that the footprint is the sign left by the foot of the man or the animal on the ground through which it passes. More precisely, the carbon footprint is defined as the totality of greenhouse gases emitted directly or indirectly by an individual, organization, event or product.

Since we are talking about greenhouse gases, let's identify the main ones:

- Water vapour (H2O): Odourless and colourless gas obtained by evaporation or boiling of liquid water or by sublimation of ice. It is the one that contributes most to the greenhouse effect due to the absorption of infrared rays.
- Carbon dioxide (CO2): Also called carbon dioxide.
- Methane (CH4): It is the simplest alkane hydrocarbon. It is colourless and odourless and hardly soluble in water in its liquid phase. In nature it is produced as a final product of the anaerobic decomposition of plants. It is a GHG about 23 times more powerful than CO2.
- Nitrogen oxides (NOx): These are several binary gaseous chemical compounds formed by the combination of oxygen and nitrogen. The most common process of formation of these inorganic compounds is combustion at high temperatures, a process in which air is usually the oxidizer.
- Ozone (O3): A substance whose molecule is composed of three oxygen atoms.
- Chlorofluorocarbons (CFCs): Derivatives of saturated hydrocarbons obtained by replacing hydrogen atoms with mainly fluorine and chlorine atoms. They have been widely used as refrigerant gases, extinguishing agents and propellants for aerosols.





Estros son mis datos registrados de acuerdo a la pagina https://calculator.carbonfootprint.com

VII. NOM-035 STPS 2018

NOM-035 STPS 2018 aims to establish the elements to identify, analyze and prevent psychosocial risk factors, as well as to promote a favorable organizational environment in the work centers. NOM-035 is applied to the oil platform in the inspection of its installations, to carry out visual or data surveys in order to obtain a detailed vision of the areas where anomalies are presumed, whether for corrective or predictive maintenance purposes. In order to comply with the psychosocial risk factors Identification, analysis and prevention will take into account the following points:

- To have a policy for the prevention of psychosocial risk.
- Disseminate and provide information to workers on the policy, preventive and corrective actions adopted for the prevention of these risks and the handling of drones within oil platform inspections.
- Adopt measures to prevent and control psychosocial risks.
- Identify workers who were subjected to severe traumatic events and channel them for care.
- To have a record of the results of the identification and analysis of psychosocial risk factors, in addition, in the case of workplaces with more than 50 workers, evaluations of the organizational environment.

It should be noted that this is a benefit or advantage for workers who are exposed to high-risk jobs.

Depending on the type of sensor used, it is possible to detect cracks and corrosion, so that previous evaluations can verify its evolution. The lowering of the risk index is another point in favour since with our proposal the exposure of the human element is avoided, at least for this inspection stage.

This norm is understood by two very important aspects that we will mention next:

Favorable organizational environment: In order to identify a favorable organizational environment, it is necessary to take into account that the workers must have the sense of belonging to the company, as well as the adequate communication of the work regulated by the LFT.

Psychosocial risk factors: These are all those that can cause anxiety disorders, not organic of the sleep or wake cycle, of serious stress and of adaptation, derived from the

nature of the functions of the job, the type of working day and the exposure to severe traumatic events or acts of violence in the workplace to the worker, due to the work carried out. This regulation is only applicable in country's territory and in all work centres. There are three categories, depending on the number of workers working there.

In this project it will be catalogued in the work center where less than 15 workers work which consists of:

- To establish, implement, maintain and disseminate in the workplace a policy for the prevention of psychosocial risks that contemplates: the prevention of psychosocial risk factors; the prevention of violence in the workplace and the promotion of a favourably organisational environment.
- To adopt measures to prevent psychosocial risk factors, to promote a favourably organisational environment, así as well as to address practices opposed to a favourably organisational environment and acts of violence in the workplace.
- Identify workers who were subjected to severe traumatic events during or on the occasion of work and channel them to care.

Disseminate and provide information to workers.

A course is implemented to implement a prevention against risks that may have the workers course that is supported by the STPS this course leads to a few hours of training for those workers selected for such tasks of handling the drones this in order to accredit the skills of them.

The advantages of implementing drones in the inspection of oil platforms is to lower the level of risk to the lives of workers who are dedicated to the inspection of anomalies found on them. The prevailing regulations in Mexico for the operation of drones are known, as well as the basic principles for the flight mechanics of multi-rotors under a safe environment and expressly arranged for working hours.

VIII. REFERENCES

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