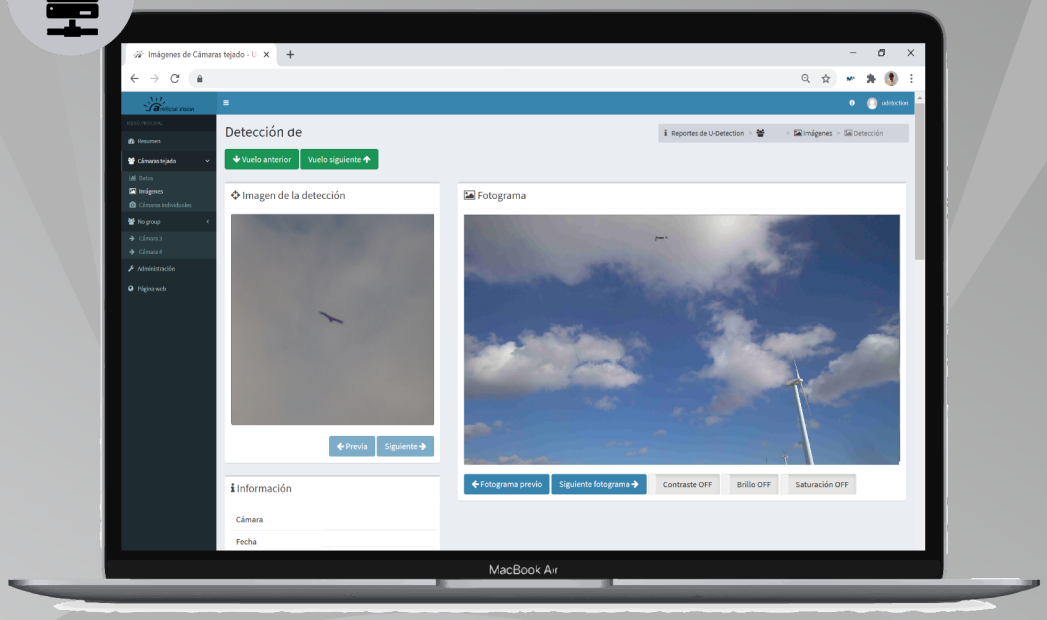
airelectronics

ARTIFICIAL VISION

# System User Manual

V 1.11

2025/03/10



# Table of Contents

# 1. General System Introduction

ArtificialVision has developed a comprehensive solution for detecting birds of prey near wind turbines using artificial intelligence and 4K stereoscopic cameras. The system is capable of stopping or slowing down the turbine to maximize bird protection while minimizing production losses. This technology has been developed and refined over several years, and has been tested in collaboration with some of the world's leading turbine manufacturers and energy operators. This is the technical manual and must be read carefully by all users before operating the system. For any questions or further assistance, please contact us at **info@artificialvision.es**.

The system is composed of:

- Detection module
- Deterrence module
- Stop module
- Reports module

**Detection module** consists of a specific powerful hardware adapted to being fully capable of detecting any bird that is wanted in a video stream of 4K resolution. Each Detection module manages:

Four 4K cameras for Artificial Intelligence

Four 4K cameras for Stereoscopic Vision

**Deterrence module** consists of 4 powerful speakers that emit a sound in order to warn or scare away the detected bird. The Deterrence module action is strongly associated with distance ranges defined by the user on the Reports module.

**Stop module** The system is capable of stopping the wind turbine, reducing its RPMs, or activating multi-turbine shutdowns — where not only the affected turbine is stopped, but also its neighboring units — to maximize bird protection. While this multi-stop strategy increases the level of protection, it may also lead to higher production losses.

**Reports module** acts as a server of data in which the user can find information related to each detection done by the system. The user can easily check an extracted image of the detection from the video stream, the date and hour of the detection, the distance of the detection, altitude, coordinatesetc. In addition, the module can generate graphs depending on all these parameters and detailed reports for the user. The user can access to this reports using a standard web browser. It is also possible to download system data via the API, with information provided in JSON format or download a CSV file. This feature offers an excellent solution for integrating the system with other IT infrastructures or software platforms, enabling seamless interoperability and enhanced automation capabilities.

## 1.1 Concept of system operation

The objective of the proposed system consists of detect automatically any bird on a 4K video taken in real time. In addition, the system has to be capable of performing actions in consequence (dissuade the detected animal for example), if it's part of the main objective.

For this, Artificial Vision has designed the following modules:

- **Detection module**:

*Figure 1: Detection module*

Station made up of eight 4K cameras with automatic object detection by means of Artificial Intelligence and stereoscopic vision. Artificial Vision will prepare the module in order to detect the desired object. The module is communicated with the remaining system components and informs about all the detected objects and related information in real time.

- **Deterrence module:**

*Figure 2: Deterrence module*

Real-time, unattended interaction with systems to scare off animals or persons that have been detected under specific conditions (distance from the camera, number of detected animals or persons, etc.). Mainly, it consists of a powerful speaker connected to the Detection module that reproduces a specific sound of dissuasion.

The Deterrence module is designed in order to reach up to 100 meters, so it's capable of emitting a sound up to 130 dB to a distance of 1 meter, a **dangerous quantity for the human audition system**. For this, the Deterrence module has to be treated **carefully**.

- **Reports module:**

*Figure 3: Reports module*

Data server that stores information about all the detections made by the Detection module. Images of the detected objects, sorted by date and hour, distance to the camera, etc., can be found, as charts resuming the Detection module activity.

A diagram of the system is shown below.

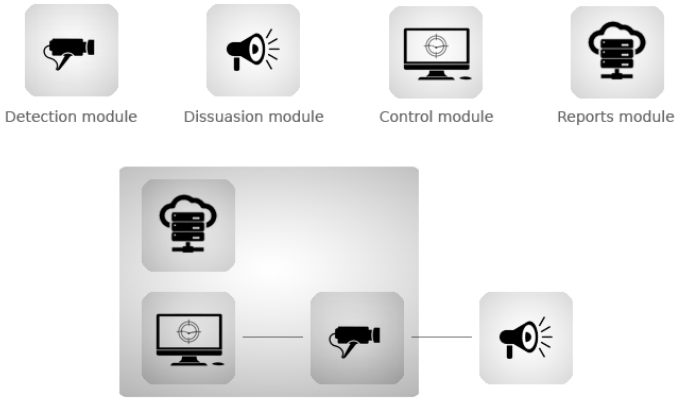



*Figure 4: Standard system diagram*

The standard configuration consists of a Detection module communicated with a Stop & Deterrence module with eight 4K cameras. A real-time video streaming is sent to the Detection module from the cameras and the Deterrence/ Stop modules acts if conditions defined on the Control module have been reached. Finally, Reports module informs about all the detections made by the system from its start-up.

The Reports module needs to be connected to each Detection module placed on the WTG using a predefined local network. Once this configuration has been configured properly, the Reports module will show information related to each Detection module (detections, cameras, etc.) and options associated to each Deterrence and Stop module.

Artificial Vision can adapt the system to the client's necessities. Contact us if you need a specific configuration.

# 2 Detection module

## 2.1 Introduction

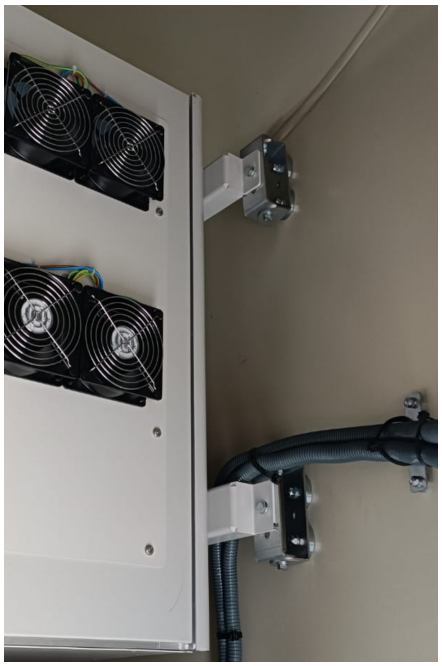
The main element of the whole system is the Detection module. This module lets the system automatically detect objects that appear in a 4K video stream in real time. For achieving this, the module includes a powerful GPU technology specially configured by Artificial Vision.

The module is normally supplied in a robust rack enclosure prepared for tolerating extreme ambient conditions and is water-resistance and dust-resistance. This enclosure includes:

- A Detection module..
- A Switch.
- 3G/4G modem (optional)

*Figure 5: U-Detection rack inside WTG*


*Illustration 1: Installation on the WTG*



*llustration 2: Magnets used to secure the rack in the WTG*


*Illustration 3: Installation on the WTG*

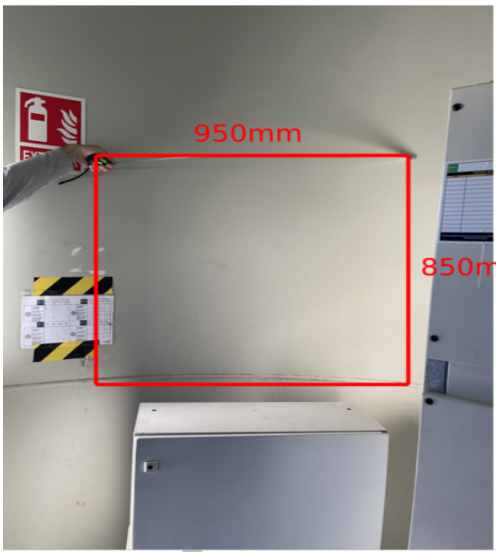



*Illustration 4: Installation on the WTG*

## 2.2 Connection configurations

From the bottom of the rack enclosure, the user could find the following connections:

- 8 Ethernet cables with PoE for the 4K cameras
- 4 Ethernet cables with PoE for the Speakers
- 1 Ethernet cable to communicate with the SET
- Air-conditioned rack

In relation to the input power supply the rack must be powered at 220V and power consumption will be 1 KW

The audio that the Deterrence module has to reproduce in order to scare off the detected animals or persons is supplied in a dedicated connection.

All the components installed in the WTG are enclosed in a rack with the following dimensions: 950x465x850mm (WxDxH)

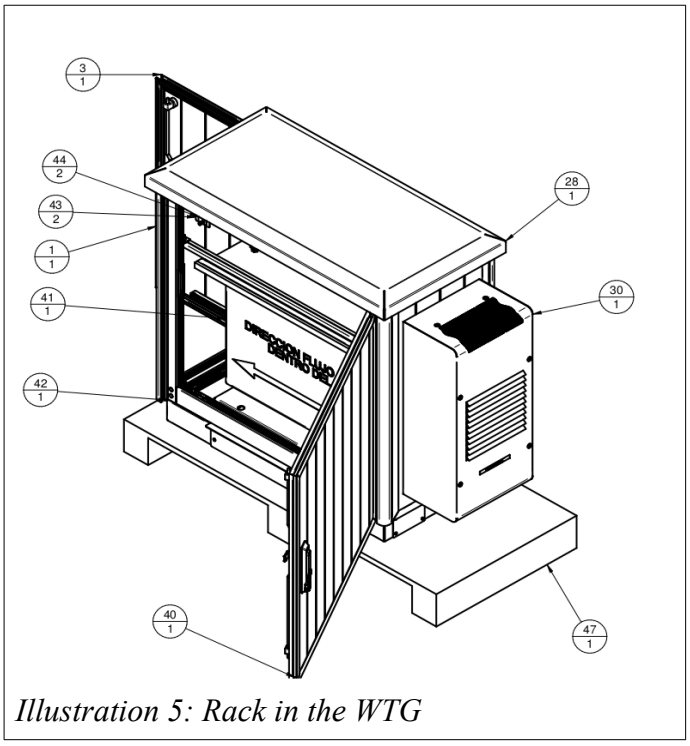



*Illustration 5: Rack in the WTG*

For external communications (mainly with the SET), the Detection module can use a Ethernet connection using a switch included in the rack enclosure. Artificial Vision recommends to use a local network formed by all the Detection modules and the Reports module using an Ethernet connector exposed on the bottom of the rack enclosure.Each connection will be tagged correctly for an easy connection or component replacement.

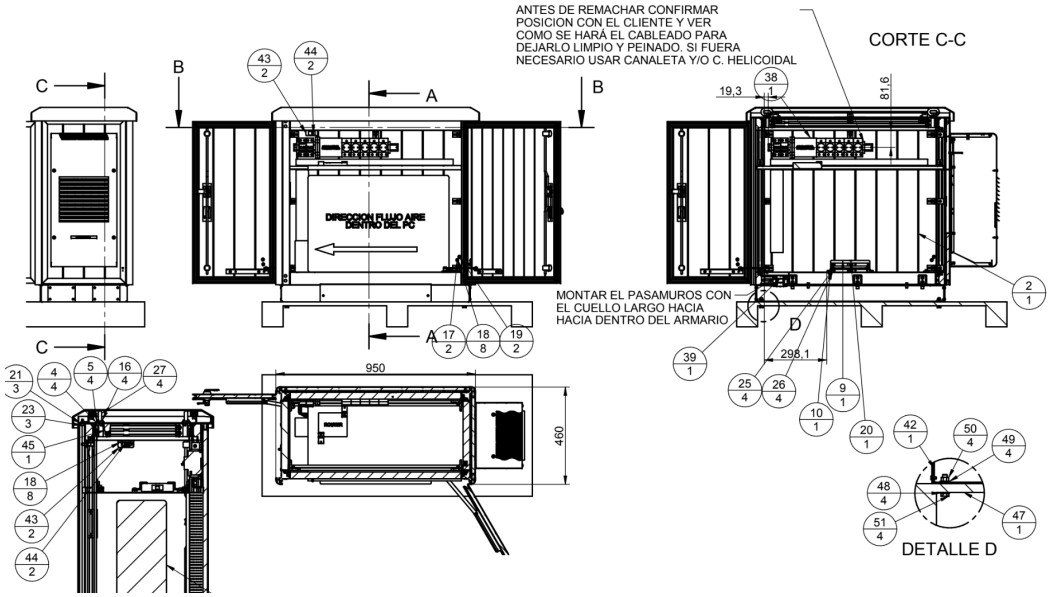



*Figure 6: Rack ·3D views*

Depending on the temperature conditions where the rack is located, Artificial Vision will provide a rack with built-in air conditioning.

These configurations are not fixed and Artificial Vision could adapt this enclosure to your necessities.

## 2.3 Power Suppply

Artificial Vision's rack is powered from the X6 connection point, which has a magnetothermic switch FM004.

*Illustration 6: ArtificialVision U-Detection installed in WTG's first floor*


*Illustration 7: ArtificialVision power protection FM004*

## 2.4 4K cameras (included with Detection module)

Artificial Vision supplies 8 high-quality 4K cameras specially prepared for any ambient conditions. These cameras are in a robust and conditioned enclosure. In addition, it is resistance to water and dust, in order to avoid possible false positives detections.

As is exposed previously, the rack enclosure has an Ethernet output cable destined to the 4K cameras associated to the Detection.

*Figure 7: 4K camera with anti ice roof*

All cameras are protected with an anti ice protection roof and are attached to the WTG with neodymium magnets and two steel cables.

*Figure 8: Camera Installation Example*

*Figure 9: Camera Installation Example*

## 2.5 External wiring

The cables are passed through a special weatherproof and insulated fitting.

To pass the 12 cables, two **24 mm hole would are used.** The drilling has been done in the front part of the door, near its filters. The cable has enough clearance to allow the operation of the door, both from the inside and outside.

*Illustration 8: Wiring through WTG door*

*Illustration 9: Wiring through WTG door*

## 2.6 Stereoscopic 3D Vision

Although the perception of birds distances and three-dimensional position is possible with information visible from just one 4K camera alone, the distance estimation is not as good as that obtained from a pair of 4K cameras working together; what is colloquially referred to as seeing "in 3D". In order to improve this distance estimation, it is possible to install a second set of cameras in parallel to the existing ones, that is, for each 4K camera a second 4K camera is installed in parallel a few meters away facing the same direction.

By comparing birds coordinates from two vantage points, 3D information can be extracted by examining the relative positions of the birds in the two 4K cameras. This is similar to the biological process of stereopsis.

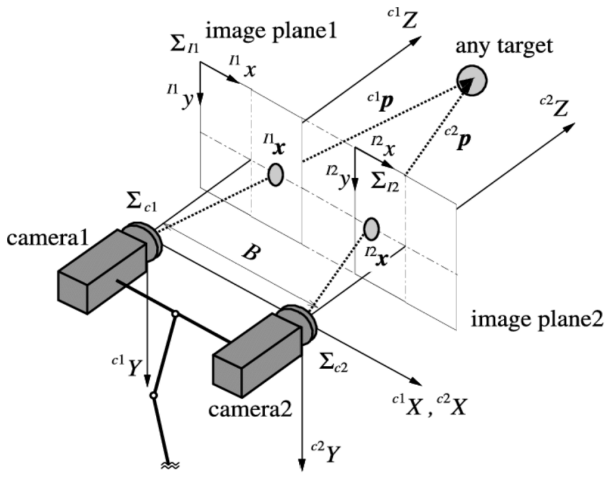



*Figure 10: 4K cameras mounted in the WTG. Top View*

In order to improve accuracy the system performs independent calibration, rectification and demosaicing of raw stereo camera image pairs.

All the algorithms have been designed in such a way that they do not slow down the detection speed of the birds and so that they work in a robust way. Regardless of whether the system uses 3D vision or not, the rest of the ArtificialVision products are compatible, that is, the reporting system works with the standard camera configuration or with the stereoscopic camera configuration.

# 3 Deterrence module

Deterrence module consists of 4 powerful speakers capable of emit a sound up to 110dB to a 1 meter of distance from it and an efficient amplifier placed on the Detection module that powers up the sound received by the speaker. This features lets the system to reach up to 1 kilometer with an audible sound. However, the user has to be careful with the Deterrence module because the human audition system can be damaged permanently with a sound of 110dB. So, stay away from the Deterrence module to avoid this powerful sound or use ear defenders.

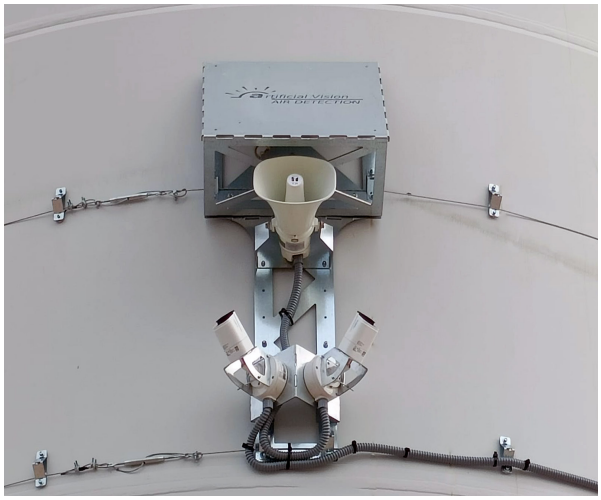


*Figure 11: Deterrence module's speaker*

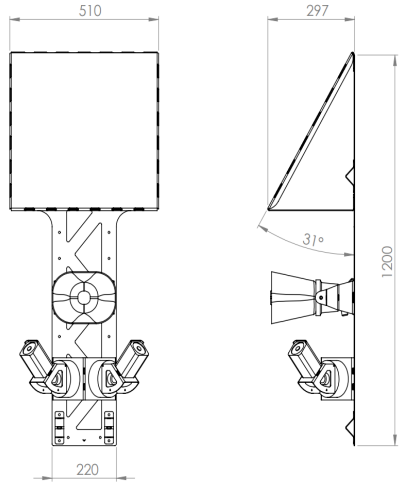



*Figure 12: Deterrence module's speaker*

There is only a connection between the Detection module and the Deterrence module, the one used to supply the audio to the speaker.

The standard configuration consists of using 4 speaker per WTG included on the system.

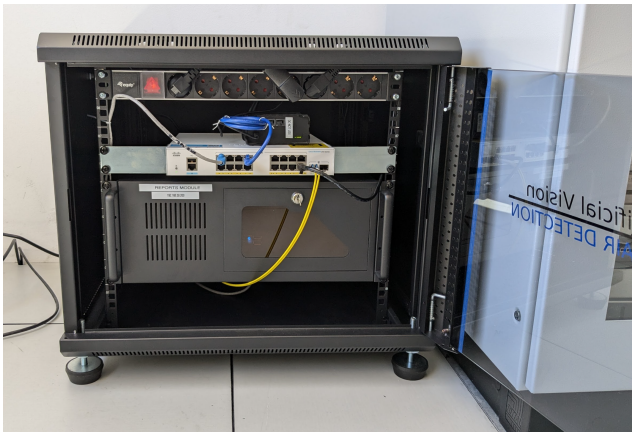
# 4 Stop Module

Stop modules includes the necessary hardware to send a stop signal to the WTG SCADA .

Down time and start-up programmable in the detection module computer.

The module consist in a device connected to the wind turbine control computer and the Detection Module installed in the SET


*llustration 10: Artificial Visions Stop Module and Reports Module*



*llustration 11: Artificial Visions Stop Module and Reports Module*

*lustration 12: Artificial Visions Stop Module and Reports Module*

Downtime and restart period are programmable on the Detection Module computer.

Stop module have 2 independent Network Interfaces, one is communication only with the SCADA and another one is communicating with the WTGs

Any SCADA protocol can be customized and programmed. The most common protocols already integrated by ArtificialVision are:

- Modbus TCP
- IoT Azure
- OPC XML DA
- OPC UA

## 4.1 Multi Stop

It is possible for each system to protect not only a single wind turbine independently, but also to command multiple shutdowns. This means that if a threat is detected for one turbine, it can also stop its neighboring turbines.

If the client is interested, ArtificialVision needs this information to implement the functionality.

While this may result in a slight loss of production, it significantly enhances protection and minimizes mortality. Reports Module

## 4.2 License dongle

The Detection module needs a license dongle connected to one of its USB ports in order to work properly. This dongle is supplied with the product and connected to the Detection module in the rack enclosure by default.

If the dongle is damaged or is lost, please contact to Artificial Vision.

# 5 Reports

## 5.1 Introduction

The data generated by the detection systems is synchronized with a computer or central server, which collects, processes, and displays the data for the user's convenience. For the user, the reporting system is a web portal, compatible with the latest versions of browsers.
This section aims to explain the various visualization and data collection features available to the user and how to make the most of them.
This document assumes that the user has read and understood the U-Detection user manual. The following explanation will focus solely on the functionality of the reporting module. If you need access to other documents, please visit our website at www.artificialvision.es, where all documents are published.

## 5.2 Requirements

### 5.2.1 Data Visualization

The only requirement to access the reporting system and visualize data is having an internet connection of at least 10Mbps and a compatible browser, such as the following:

- Google Chrome
- Mozilla Firefox
- Microsoft Edge

To ensure maximum compatibility, it is recommended to keep the browser updated, with no more than 2 years of age.

It is also highly recommended to have a screen resolution of at least 1366x768.

### 5.2.2 Data Export

In addition to these requirements, other tools may be needed to utilize data export, such as:

- PDF viewer (Adobe Reader, Sumatra PDF, etc.)
- .zip file extractor (the built-in Windows 10 explorer, 7zip, WinRAR, etc.)
- Spreadsheet processor (Microsoft Office Excel, LibreOffice Calc, etc.)

## 5.3 Access

To access the system, enter the web address (URL) provided by Artificial Vision in the browser's address bar. Then, the login credentials (username and password) will be requested, where you need to specify the details provided by Artificial Vision.

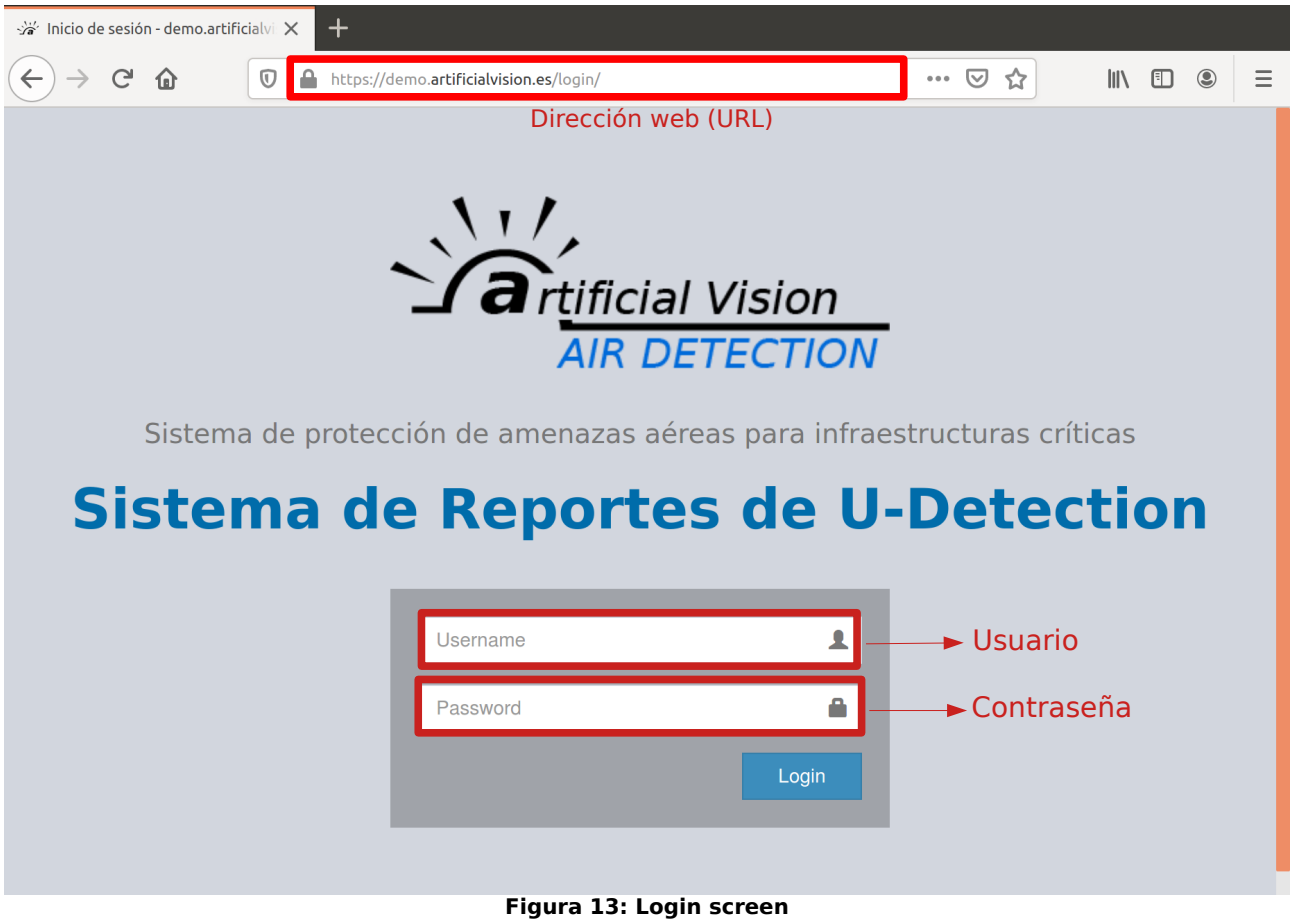



**Figura 13: Login screen**

Each project and user has their own access address and username/password. If you do not know yours, please contact us at info@artificialvision.es.
The system will automatically log out after 10 minutes of inactivity or when the browser is closed.

## 5.4 Basic Concepts

For system operation, there are several concepts that are mentioned when visualizing the data, and it is important to understand them:

### 5.4.1 Detection

A detection is the basic unit of information in the system, generated by the detection modules. It corresponds to an individual detected at a specific moment in time and at a specific position in the image. Detections are associated with an image of resolution

512x512, where the detection is cropped in the center, and with an image of the full view (frame) at the same moment, which may contain other detections. The same individual may generate multiple detections

### 7.4.2 Cámara

The cameras displayed in the reporting system correspond to each of the physically installed cameras, and each one has a section where the information generated by that camera is collected.

### 5.4.2 Group

A group corresponds to a geographic location where a series of cameras are located, and whose data is desired to be viewed as a collective. The information displayed in this section is, therefore, a combination of data from all the cameras within that group.

### 5.4.3 Flight

A flight is a consecutive grouping of detections that are correlated over time within an interval shorter than a parameter configured in the system. Depending on whether flights are being viewed for a group or a camera, these flights will group detections associated with an individual camera or with the cameras that make up the group.

There are different types of flights:

- **Normal Flight**: Normal flights, associated with the green color, are those where the system determines that there was no risk or dangerous situation for the specimen(s) recorded in that flight.
- **Risk Flight or WARNING**: Risk flights, associated with the yellow color, are those in which, based on configured parameters, the system determined that there was a risk to the integrity of the individual(s) recorded. The most relevant parameter is the distance of the observed detections.
- **Dangerous Flight or DANGEROUS**: Dangerous flights, associated with the red color, follow the same logic as risk flights but with a different distance threshold.

The values of the parameters mentioned in this section can be viewed on the website. After logging in, an icon with an "i" will appear in the top right corner of the website, just to the left of the username. By clicking on the icon, this information will appear as shown in **Figure 15: Flight Parameters Visualization**.

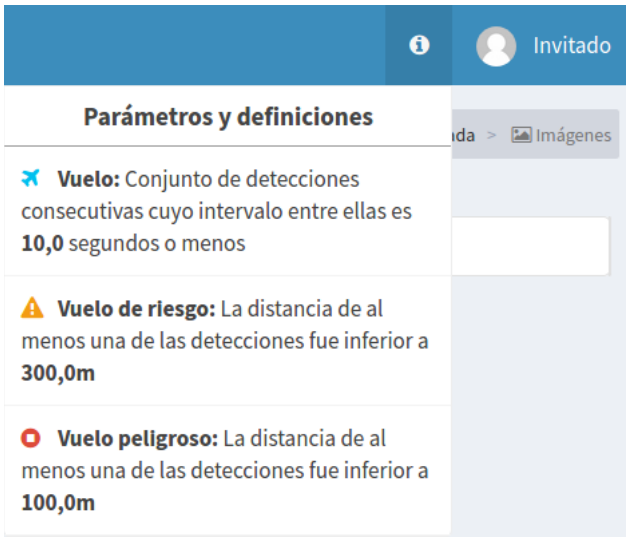



**Figura 14: Visualización de parámetros de vuelos**

## 5.5 Data Visualization

### 5.5.1 Structure

Once the user has logged in, they can click on "Enter" and access the system's main page, the "Summary" page.
On the left side of the page, there is a navigation menu. It lists the different sections of the website:

- **Summary**: A summary of the data collected by the system up to the current moment. See Summary.
- **Groups**: Below, all configured groups are listed, with the following available options for each group:
  - **Data**: In this section, data for the grouped detections of the group can be viewed. See Data.
  - **Images**: In this section, the images of the detections, organized by flights and collected by the group, can be viewed. See Images.
  - **Individual Cameras**: Here, all the cameras contained in the group are listed, each having the following options:

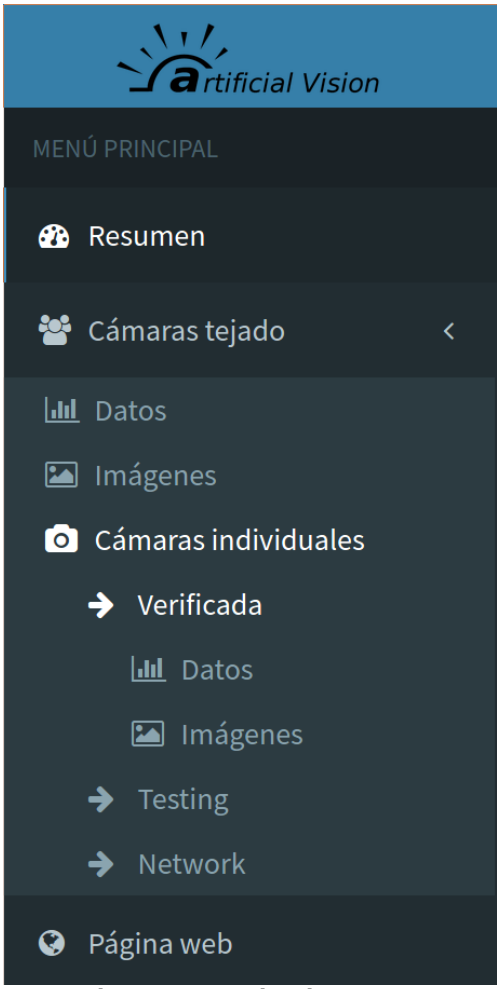



**Figura 15: Navigation menu**

- **Data**: In this section, data for the grouped detections of the specific camera can be viewed. See Data.
- **Images**: In this section, the images of the detections, organized by flights and collected by the camera, can be viewed. See Images.

- Lastly, a link to the **Artificial Vision** corporate website.

On the other hand, in the top right corner of the page, there is a navigation guide that shows the user which page they are on and the page's hierarchy within the website. It can also be used to navigate backward from a page to other pages that depend on it.

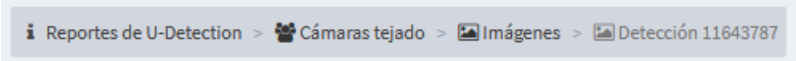



**Figura 16: Navigation Guide**
**In the image, the user is viewing a detection event captured by the camera group named 'Cámaras tejado'.**

## 5.5.2 Summary

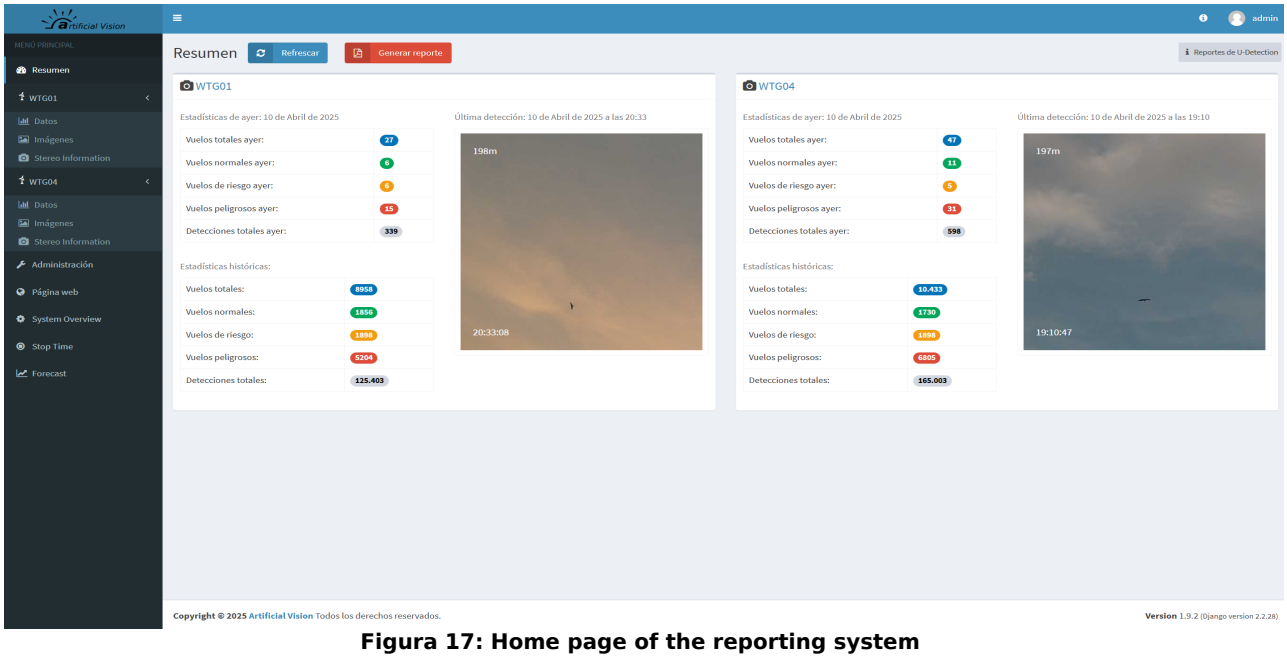



**Figura 17: Home page of the reporting system**

The first thing seen upon accessing the system is a summary of the data collected by the system up to the present moment. This summary displays boxes for each available group, along with the data associated with them.
In the title of each box, the group name is shown. By clicking on the name, the "Data" page for that group will open.

Inside the box, there are two columns:

- **In the left column**:

    - The total number of flights, organized by flight type (normal, risk, and dangerous), and the total number of detections associated with the previous day.
    - The same data, but collected from the first day the system started detecting, i.e., historical data.
- **In the right column**:
    - The most recent detection for the group, with information about the camera that detected it, the time, and the detection distance.

Clicking on the "Refresh" button will update the information to the current moment, if new data is available.

### 5.5.3 Data

The "Data" page displays summarized and graphical information associated with a camera or a group of cameras regarding flights and detections. It is useful for studying the general distribution and density of flights and/or detections associated with a camera or a set of cameras.

The "Data" page, by default, appears as follows:


**Figura 18: Data**

Before discussing the two main elements of this section, it is important to highlight:

- In the top left, there will be an indication of which camera or group of cameras is providing the data to be visualized. This identification is made through the name of the camera or group, along with an associated identifier number assigned by the system.
- The amount of data to be visualized directly depends on a date range selected by the user, which can be set using the selector located below the camera or group identifier. Once the date range is selected, clicking "View" will update the page with the data obtained by the system within that date range.

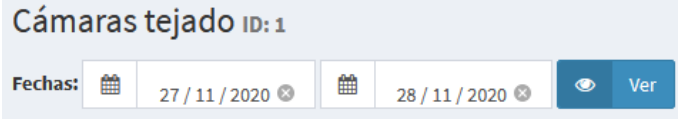



**Figura 19: Camera or camera group identifier and date range selector**

- If you wish to view the flights and detections by their image within the selected date range, you can use the "Images" button, located next to the date range selector.

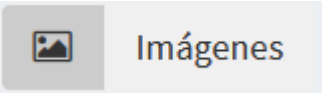



**Figura 20: Images button**

The elements that make up the visualization are detailed below.

### 5.5.4 Graph

This element displays the number of flights and detections in the form of a bar graph, based on the hour, day, or month, depending on the selected date range. In these graphs, each bar represents the number of flights or detections, depending on what is selected in the dropdown in the top-right corner of the graph. By default, information related to flights will be shown.

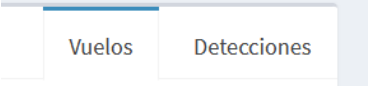



**Figura 21: Graph selector**

If "Flights" has been selected, the bars will represent the number of flights detected during the specified time unit, including information about the types of flights detected through color bands within the same bar. If the user hovers the mouse over these color bands, they will find information about the number of flights of the specific type detected. Below the graph, there is a legend explaining the meaning of each color, where the visualization of a specific flight type can be disabled by clicking on its associated color icon.

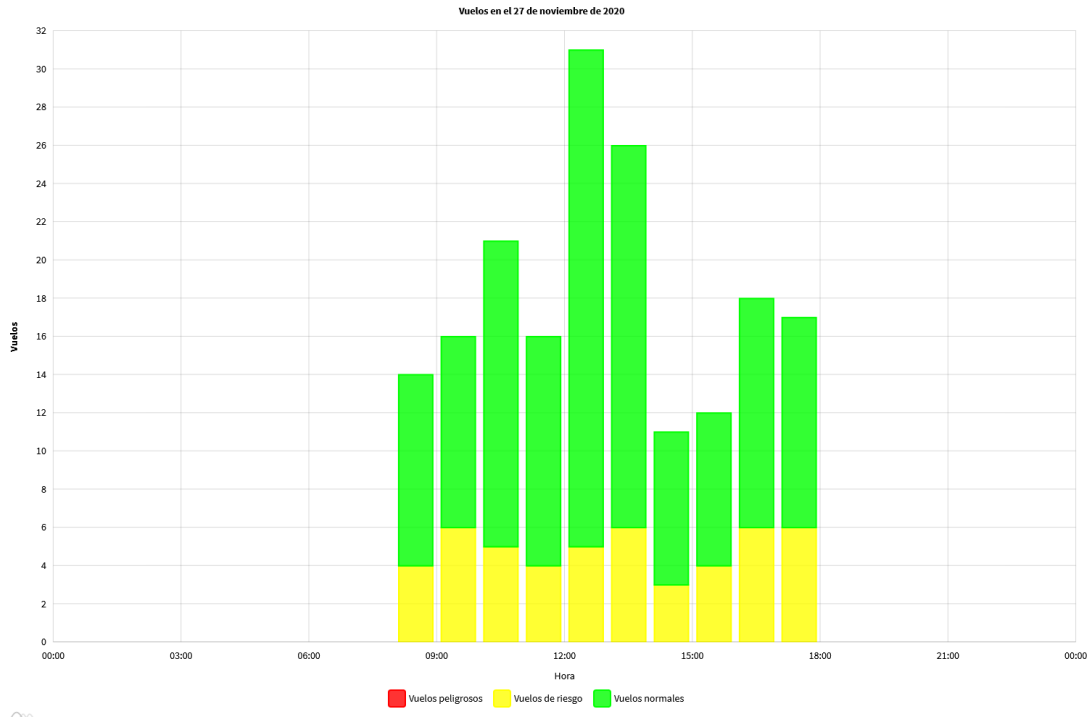



**Figura 22: Chart displaying the bird flights detected on a given day**

If "Detections" has been selected, the color bands will provide information about the number of detections for each distance range defined in the system, which are as follows:

- Detection more than 1000 meters.
- Detection between 800 and 1000 meters.
- Detection between 600 and 800 meters.
- Detection between 400 and 600 meters.
- Detection between 200 and 100 meters.
- Detection less than 100 meters.

Except for these differences, the graph and its functionalities are similar to those explained for the flight graph.

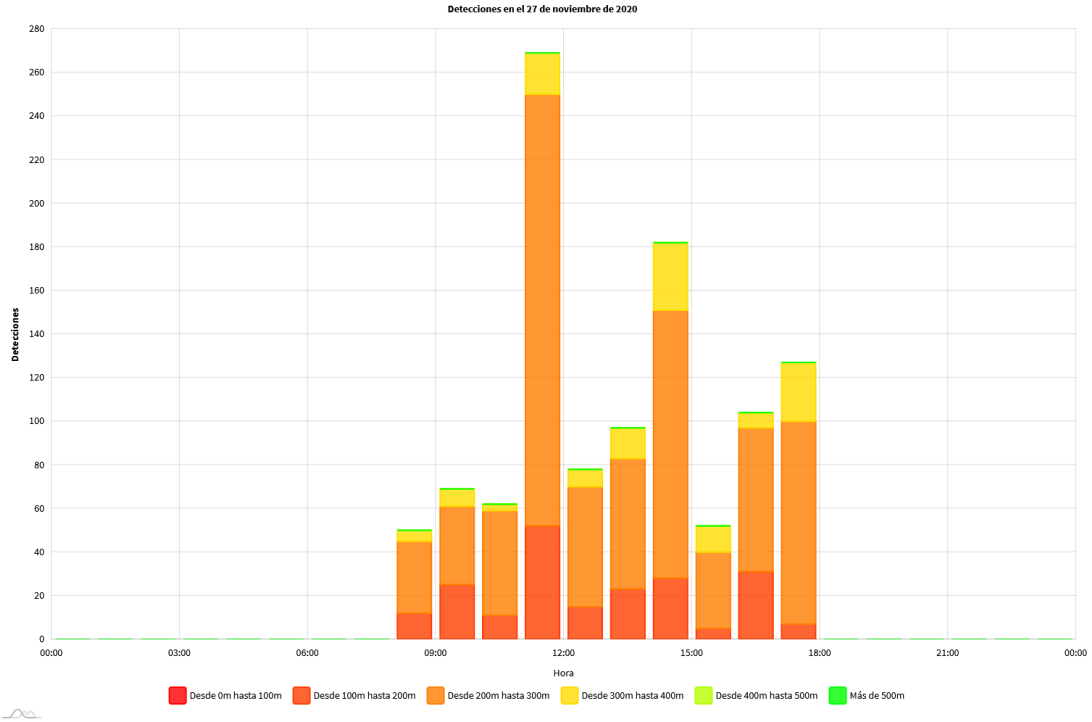



**Figura 23: Gráfica mostrando las detecciones realizadas en un día determinado**

### 5.5.5 Map

In this other element, a geographic map can be viewed, focused on the location of the camera or group of cameras providing the data. The map displays the detections made within the selected date range, using the coordinates of each detection, along with a heatmap associated with these detections.
To toggle the visibility of the detections and/or the heatmap, click the icon located in the top-right corner of the map. By default, only the heatmap is displayed.

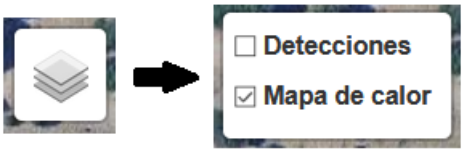



**Figura 24: Map display element selector**

The heatmap visualization provides clear information about the geographic distribution of the detections made by the camera or group of cameras. As the color of the heatmap transitions to red, the number of detections in that area will be higher.
In the top-left corner of the map, there are controls to zoom in or out on the map and to view the map in full-screen mode.
At the bottom of the map, you can select the maximum number of detections for the heatmap, which corresponds to the color closest to red. A lower value will make the heatmap take on more red tones globally, while a higher value will do the opposite, highlighting only areas with a large number of detections.

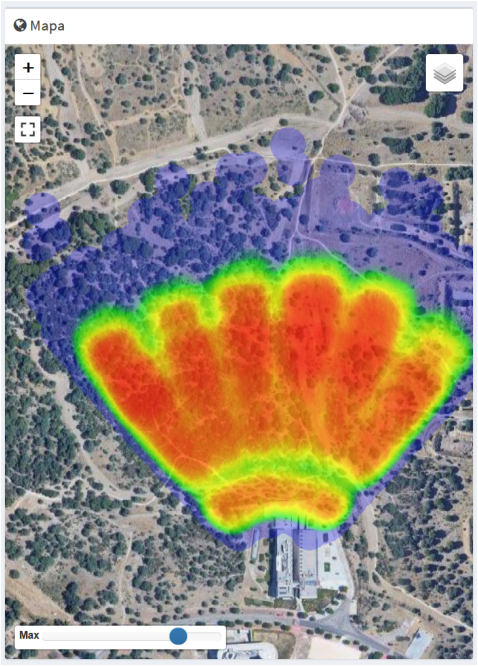



**Figura 25: heatmap**

The detections, on the other hand, can be viewed on the map in groupings. Each grouping is represented by a circle with a number indicating the amount of detections that make up the grouping. The color of the circle transitions to red tones as the number of detections in the grouping increases. By hovering the mouse over a circle of a grouping, the effective area of that grouping will be displayed, which is the area on the map where all the detections forming the grouping can be found.

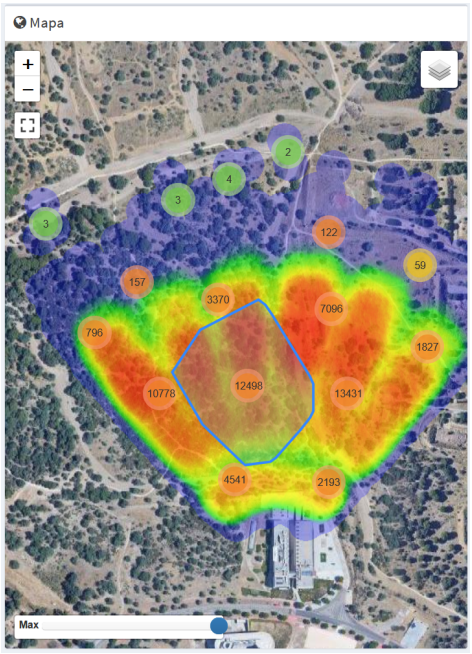



**Figura 26: Map with detection representation using clustering**

Clicking on the circle of a grouping will zoom into the area associated with that grouping, displaying new groupings with a smaller number of detections. Once zoomed into a more specific area, the detections will be shown individually with a blue location icon. By clicking on the icon, an indication of the distance, confidence, and date of the detection will appear. If you click on the text of the indication, a detailed information page for the specific detection will open, where you can view the image and other detection parameters

## 5.6 Images

On the other hand, the "Images" page focuses on displaying detections and flights through the image captured by the detection system and the camera or set of cameras.

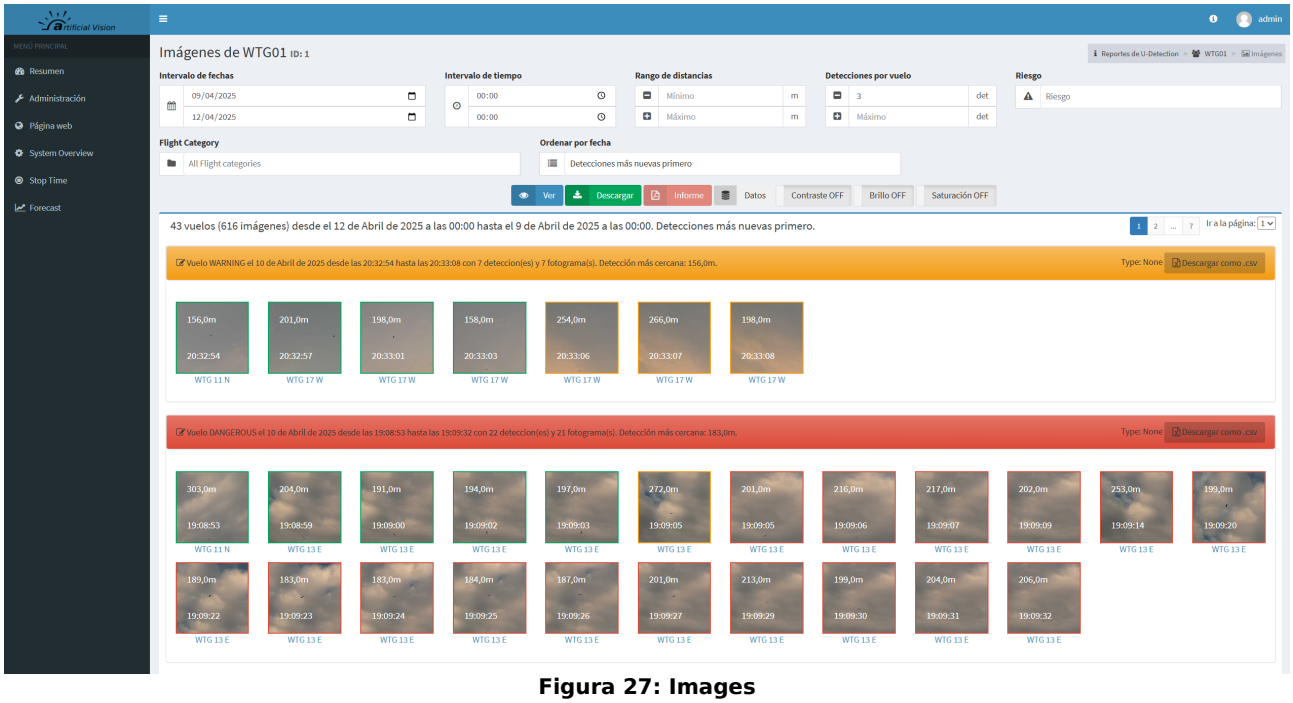



**Figura 27: Images**

Similar to the "Data" page, the user can configure a series of filters to select which images to view. These filters are summarized as follows:

- Date range
- Hour range of the day
- Distance range associated with the detections
- Number of detections per flight
- Flight risk level

Additionally, on this page, the images and flights displayed can be sorted in ascending and descending chronological order.

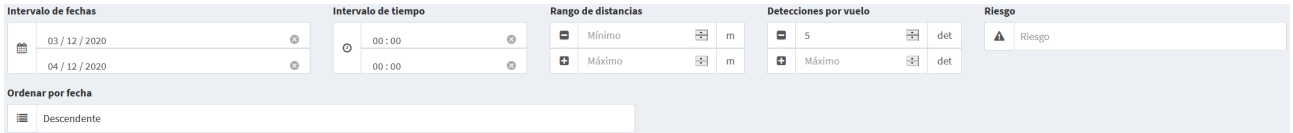



**Figura 28: Display filters available on the 'Images' page**

For the parameters set in these options to take effect, the "View" button must be clicked.

As for the visualization of the detections, it can be found just below the filtering options.


**Figura 29: Viewing images linked to detections**

The number of flights and detections that meet the parameters defined in the filters is displayed above the set of images. Additionally, the selected date range is shown. All images, as seen in the previous image, are organized by flights. Each flight is identified with a header that summarizes information associated with that flight, such as:

- **Flight risk**: Explicitly indicated by the corresponding term (e.g., "Warning") and implicitly by the color associated with that risk (e.g., orange).
- The date when the flight was detected.
- The time range during which the flight was detected.
- The number of detections for the flight.
- The number of frames that make up the flight.
- The distance of the closest detection present in the flight.

Below the header, thumbnails of each detection that makes up the flight appear. Each image is associated with the time of the detection, the distance at which it was detected, and a colored border indicating the risk level of the flight up to that detection. If images from a group are being viewed, the camera that made the detection will also be displayed below the detection preview.

Clicking on one of the images will open a preview of that image, detailing the camera that made the detection, the date and time, the distance, and the image number relative to the other images making up the flight. By pressing the 'right' and 'left' arrows on the keyboard, you can navigate through the images that make up the flight.

**Figura 30: Detailed image of a detection from the 'Images' page**

Clicking on the text below the image will open a page with specific information about the corresponding detection
If the number of images that meet the parameters set by the filters is too large, these images will be organized into pages. You can navigate between pages using the selector located in the top-right corner of the image viewer.

There are three buttons that directly affect the image display, located inline with the "View" button. These are:

- **'Contrast ON/OFF' button**: Applies a fixed amount of contrast to all the images on the current page, both in the thumbnails and in the image preview. By default, this is disabled and shows the text "Contrast OFF", but when activated, it turns blue and displays the text "Contrast ON".
- **'Brightness ON/OFF' button**: Functions similarly to the contrast button, but adjusts the brightness.

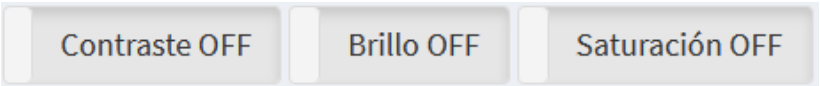



**Figura 31: Contrast ON/OFF', 'Brightness ON/OFF', and 'Saturation ON/OFF' buttons**

Finally, there is the "Data" button, which, similar to the "Images" button seen on the "Data" page, opens the "Data" page for the selected date range in the filter parameters.

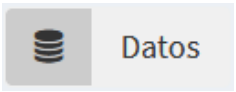



**Figura 32: 'Data' button**

## 5.7 Detections

Each detection has an associated page with specific information about it. This page can be accessed from the map on the "Data" or from the preview of a detection on the "Images".

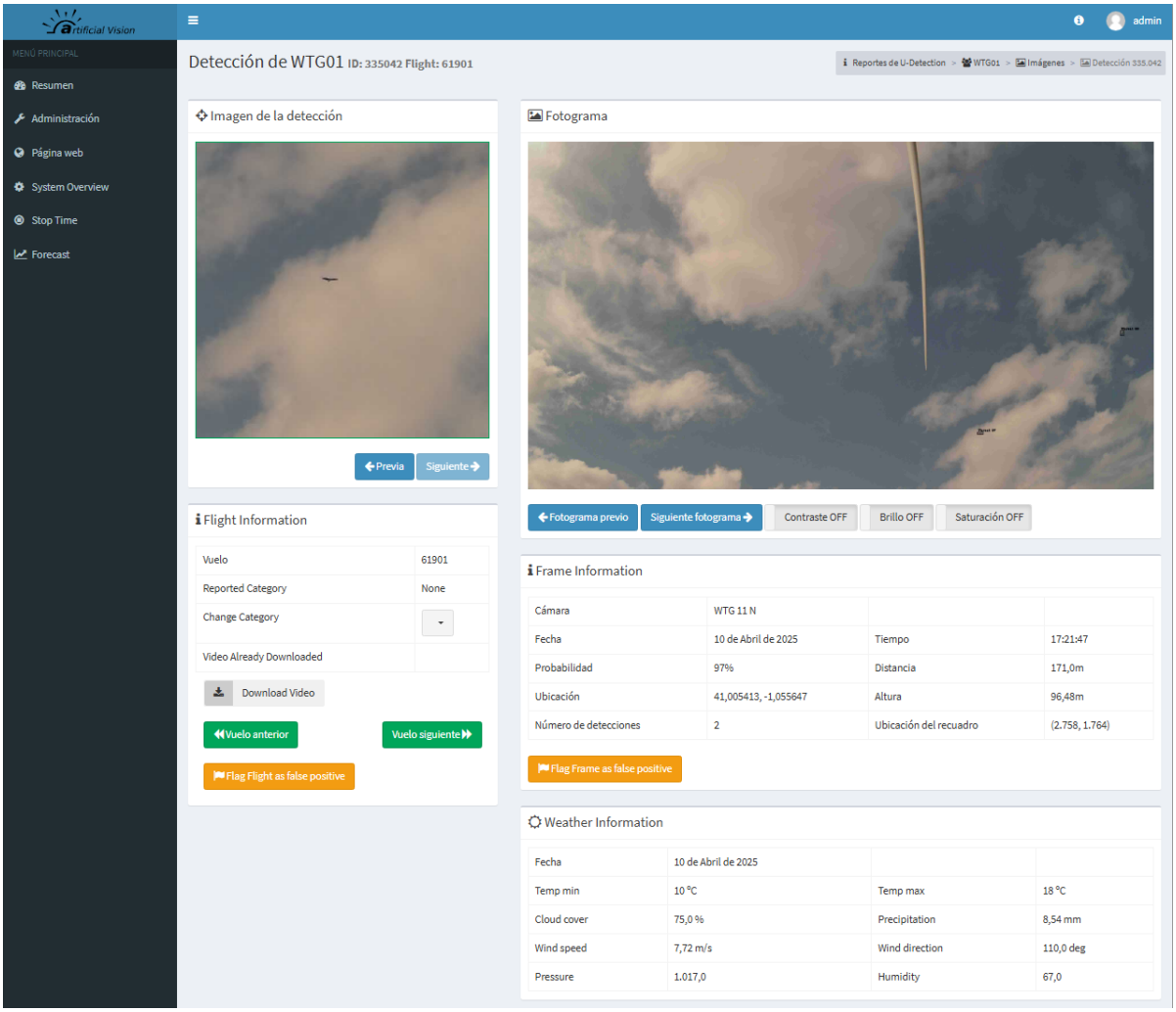



**Figura 33: Página 'Detección'**

## 5.8 High resolution detail image and low resolution frame image

On this page, the following main elements can be found:

- A detailed image of the detection, centered on the detected individual. Below, there are buttons to navigate through detections in chronological order. The 'right' and 'left' arrows will perform the same function as these buttons.

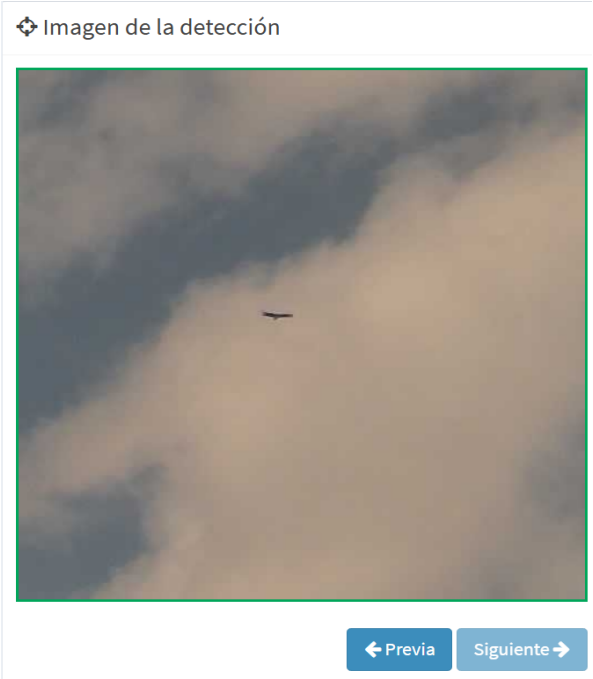



**Figura 34: Detection image**

- A low-resolution image of the frame where the individual was detected. In this image, the detections made in the frame are indicated by a black bounding box, with the detection's confidence level displayed above the box. Below the frame image, there are buttons to navigate through frames chronologically, as well as buttons to apply a fixed amount of contrast, brightness, and saturation to both the detection image and the frame image.

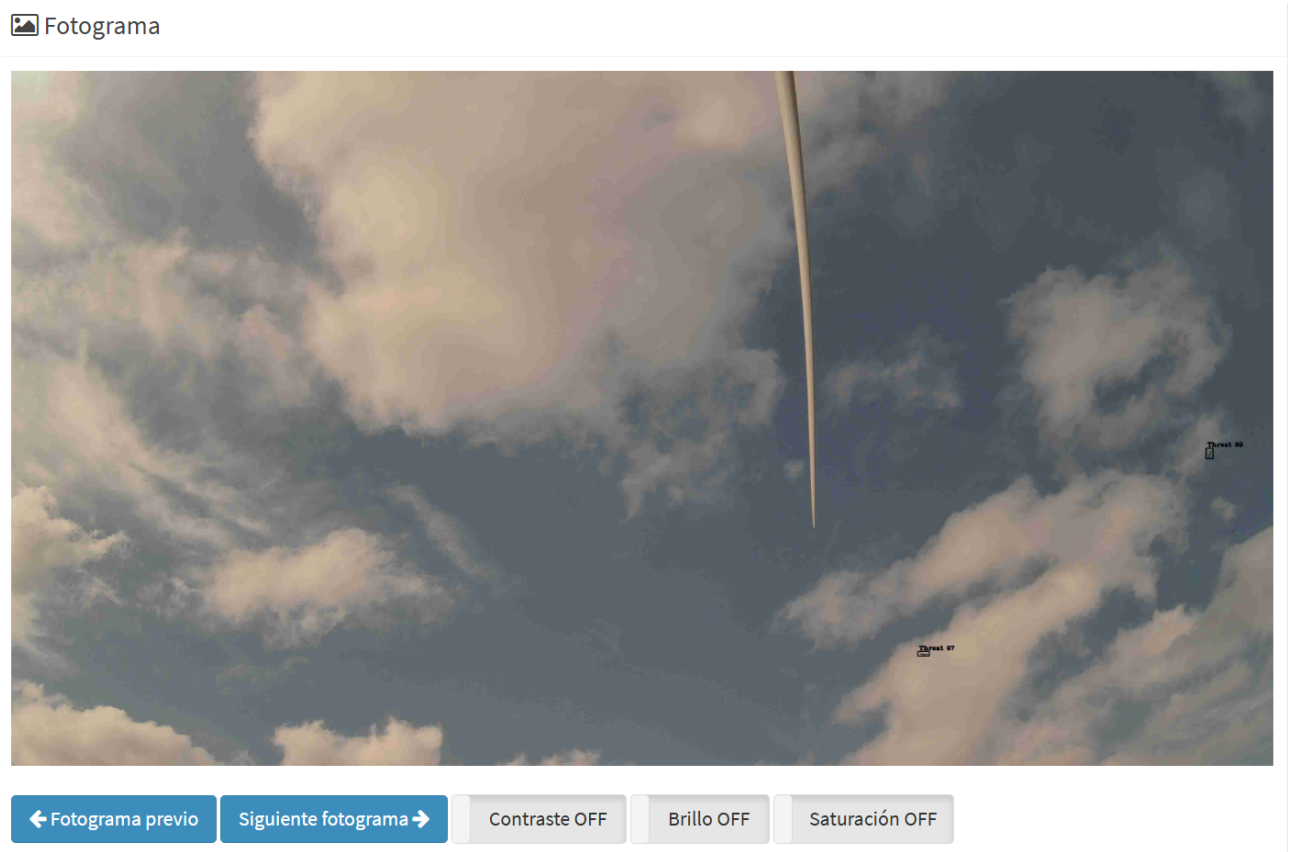



*Figure 35: Low resolution frame image*

### 5.8.1 Flight Information

Each detection event that corresponds to a bird flight is grouped under a single flight ID. All frames related to that flight share the same flight number. Additionally, if manual or automatic species classification is enabled, a species or category can be assigned to the entire flight.

From this section, users can assign a specific species or category to each flight based on visual inspection or AI suggestions. It is also possible to download the full video associated with the flight or flag the event as a false positive if necessary.

The false positive rate of the system is consistently below 1%, and such occurrences are rare. Therefore, false positives should not be a major concern for the user, but the option to review and reclassify is always available for full transparency and control.

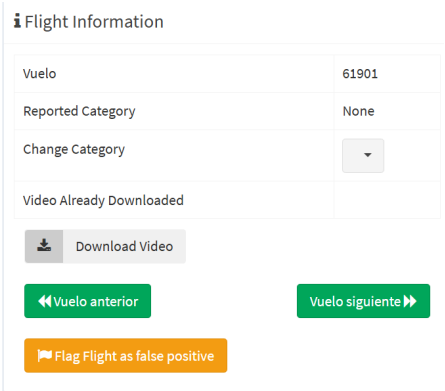



*Figure 36: Flight Information*

### 5.8.2 Frame Information

Each flight is composed of multiple frames, and each frame contains its own specific information. This includes: the camera that made the detection (North, South, East, or West), the date of the detection, the initial detection time, and the probability that the detection is valid (AI confidence level). Additionally, the frame stores the distance to the wind turbine, the height relative to the camera, and the geographic coordinates (latitude and longitude). The number of animals detected in the frame is also recorded.


*Figure 37: Frame Infomration*

### 5.8.3 Weather Information

For each flight, the system records the meteorological data at that specific time and location. These weather parameters are stored alongside the flight data and will be used to train a third artificial intelligence model. This model is designed to predict future bird flight activity over the next seven days, by extrapolating from weather forecasts to generate an activity forecast.

Users can opt to receive a daily email every morning containing this forecast. This information can be valuable for a wide range of tasks, including planning turbine operation, scheduling maintenance, or adjusting monitoring intensity based on expected bird activity.

Weather Information

| | | | |
|---|---|---|---|
| Fecha | 10 de Abril de 2025 | | |
| Temp min | 10 °C | Temp max | 18 °C |
| Cloud cover | 75,0 % | Precipitation | 8,54 mm |
| Wind speed | 7,72 m/s | Wind direction | 110,0 deg |
| Pressure | 1.017,0 | Humidity | 67,0 |

*Figure 38: Weather Information*

## 5.9 Data export

The reporting system includes a powerful data export functionality. This functionality supports multiple export formats, depending on the user's choice and the information to be exported, as will be detailed below. Additionally, depending on the page the user is on, the export options adapt to that page; therefore, this section will be organized in the same way as the previous one.

### 5.9.1 Data

The data that can be extracted in this section is limited to the data associated with the graph that shows detections and flights within the specified date range (see 8.3.1). In this regard, there are several options for exporting this information:

- By clicking the "Export" button, located inline with the date range selector, the information is exported in .csv format, which is useful for representing the data in a spreadsheet generated by programs like LibreOffice Calc or Microsoft Excel, organized in rows and columns. For this, the fields are separated by the ";" character, which should be specified as the delimiter when opening the file in these programs. The data included in the file depends on whether the graph represents flights or detections:

    - If the graph represents flights, the file will include the flights in rows, with the following columns:

- **group/camera**: Group/Camera that captured the flight.
- **start_datetime**: Date and time the flight started, expressed in UTC time.
- **end_datetime**: Date and time the flight ended, expressed in UTC time.
- **detections_count**: Number of detections that make up the flight.
- **minimum_distance**: Distance of the closest detection included in the flight.
- **maximum_detections**: Maximum number of simultaneous detections in a frame during the flight.
- **dangerous**: Whether the flight is dangerous, marked as 'True' or 'False'.
- **warning**: Whether the flight is risky, marked as 'True' or 'False'.
- If the graph represents detections, the file will include the detections in rows, with the following columns:
- **camera**: Camera that captured the detection.
- **datetime**: Date and time the detection was made, expressed in UTC time.
    -
        - `probability`: El nivel de confianza o probabilida de la detección, expresada en porcentaje.
        - `distance`: La distancia entre el individuo detectado y la cámara que lo captó.
        - `location`: La localización geográfica de la detección, expresada en latitud y longitud.

- **zone**: The zone where the detection was captured, if defined.

In the top-right corner of the graph, there is a dropdown menu that can be accessed by clicking the '...' button, where various export options are available. These options are summarized as follows:

- **Exporting graph data**: These are the same data used to represent the graph, and they are useful for reconstructing the graph in another program, for example. Access this by hovering the mouse over the '...' button and selecting 'Data'. There are three export formats available to choose from: json, csv, and xlsx. The exported data consists of a group of parameters for each of the bars visible in the graph, including:
    - **Value on the x-axis** associated with the data bar. If the date range includes only one day, this value will be an hour of the day; if the date range includes multiple days, it will be one of the days in the range.
    - **Number of dangerous flights** shown in the graph for the corresponding x-axis value (red color).
    - **Number of risk flights** shown in the graph for the corresponding x-axis value (yellow color).
    - **Number of normal flights** shown in the graph for the corresponding x-axis value (green color).
    - **Unique identifier or timestamp**.

- **Exporting the graph as an image**: The graph can also be exported as an image file. To do this, hover the mouse over the '...' button and select 'Image'. Available image formats are png, jpg, gif, svg, and pdf.
- **Printing the graph**: Finally, the graph can be printed by hovering the mouse over the '...' button and selecting 'Print'.
    - 

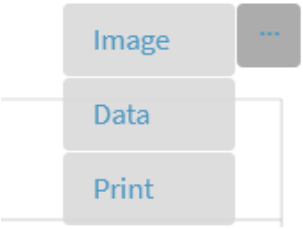



**Figura 39: Desplegable del botón '...'**

### 5.9.2 Images

On the "Images" page, the following data export options are available:

- **Detection Report**: The option to generate a PDF report with the most relevant data associated with each detection that meets the filtering parameters. The data included for each detection in the report are:
    - Date and time of the detection.
    - Probability or confidence level of the detection.
    - Distance associated with the detection.
    - Geographical location through latitude and longitude.
    - Zone where the detection took place, if defined.
    - Number of detections made in the same frame.
    - Location of the detection in the image, expressed in image coordinates in pixels.
    - Size of the bounding box, expressed in width and height in pixels.
    - Thumbnail of the detection image.

This report is limited to a maximum of 250 detections.

artificial Vision

**U-Detection reports**

**98 detecciones desde 27 de Noviembre de 2020 a las 00:00 hasta 4 de Diciembre de 2020 a las 00:00 on Network con distancias desde 0m hasta 80m**

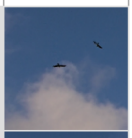
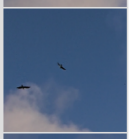
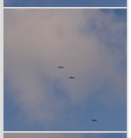
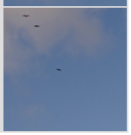
| Fecha | Tiempo | Probabilidad (%) | Distancia (m) | Ubicación | Zona | Número de detecciones | Ubicación del recuadro | Tamaño del recuadro | Imagen |
|---|---|---|---|---|---|---|---|---|---|
| 28/11/2020 | 10:47:45.814000 | 75 | 75,0 | -3,835504,40,408344 | None | 3 | 645,1168 | 63,31 |  |
| 28/11/2020 | 10:47:45.814000 | 82 | 76,0 | -3,835461,40,408379 | None | 3 | 806,1079 | 52,45 |  |
| 28/11/2020 | 10:47:45.814000 | 91 | 86,0 | -3,835269,40,40852 | None | 3 | 1450,1178 | 42,44 |  |
| 28/11/2020 | 10:47:47.126000 | 73 | 160,0 | -3,83587,40,409058 | None | 3 | 802,1626 | 27,19 |  |
| 28/11/2020 | 10:47:47.126000 | 95 | 136,0 | -3,83568,40,408894 | None | 3 | 936,1842 | 31,23 |  |

**Figura 40: Extracto de un informe de detecciones**

- **Download Images**: The "Download" button allows you to save a local copy of the images that meet the parameters defined in the filters. The images will be downloaded in a compressed zip file format.
- **Specific Flight Data in CSV Format**: In the image view, there is a "Download as .csv" button in the header of each flight, which generates a CSV file with the following data for each detection included in the flight:
- **camera**: The camera that captured the detection.
- **datetime**: Date and time of the detection, expressed in UTC time.
- **probability**: The confidence level or probability of the detection, expressed as a percentage.
- **distance**: The distance between the detected individual and the camera that captured it.
- **location**: The geographical location of the detection, expressed in latitude and longitude.
- **x, y**: The location of the detection in the frame, expressed in image coordinates in pixels.
- **w, h**: The width and height of the bounding box associated with the detection, expressed in pixels.

# 5.10 Accessing 4K WTG Videos

## 5.10.1 Introduction

The report web platform offers users the capability to access and download videos stored on the Wind Turbine Generator (WTG). In this chapter, we will outline the process for viewing and downloading videos automatically generated by the WTG in the event of bird detection in its vicinity.

### 5.10.1.1 Storage and Format of Videos

Each time an automatic detection occurs on the WTG, videos are generated for observation from four cardinal points: North, South, East, and West. These videos are stored on the platform for a period that, in most cases, does not exceed three months.

The videos are recorded in 4K format at a rate of 5 Hz, ensuring high image quality for detailed analysis of the detection. Additionally, it's important to note that each video contains a watermark.

## 5.10.2 3. Accessing Videos on the Web Platform

To access videos stored on the WTG, follow these simple steps:

- Sign in to the report web platform using your user credentials.
- Locate the specific flight

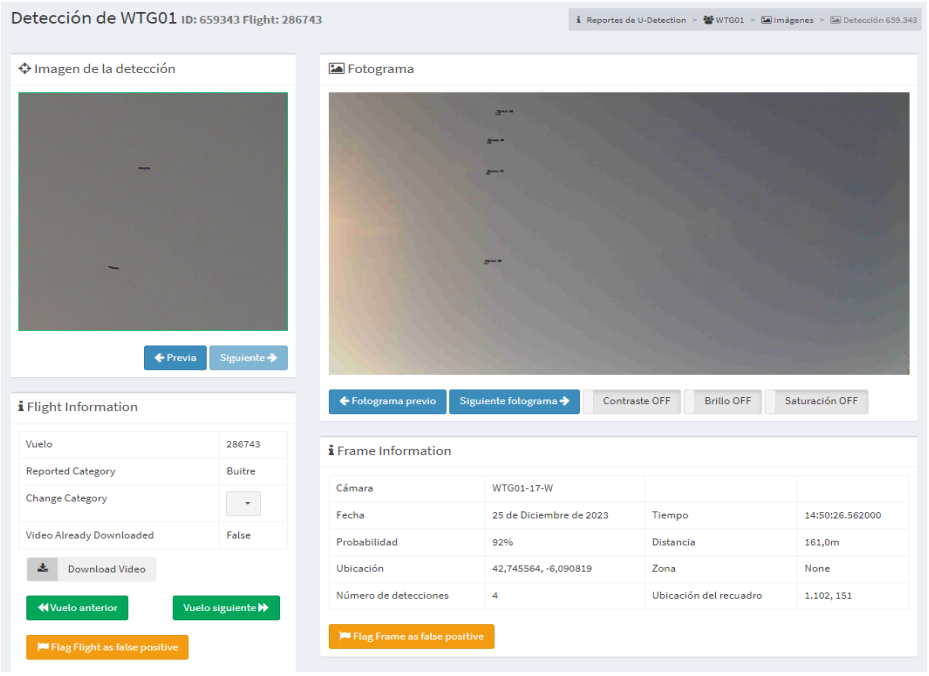



*Figure 41: Flights page*

- Click “Download Video” to open a new web browser window.
- Once inside the flight, you'll find a list of 4 associated videos. If you wish to download it, look for and select the "Download" button available on the interface.

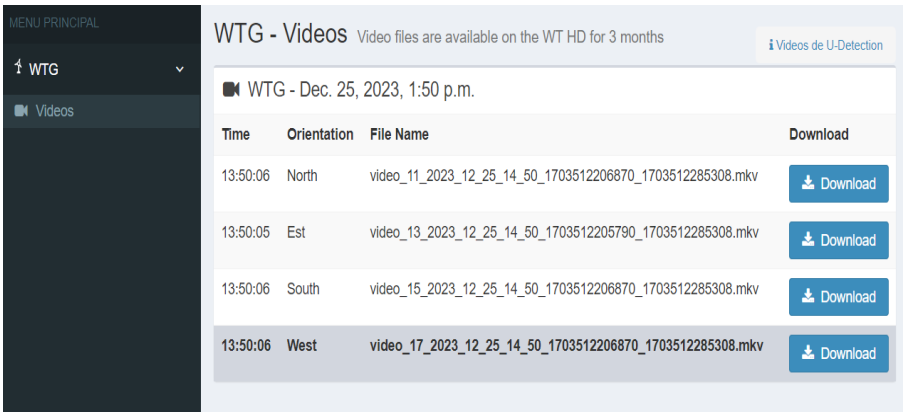



*Figure 42: WTG Video Downloa page*

In case there is a download warning please ignore it.

# 5.11 Species recognition

## 5.11.1 Introduction

Species recognition is possible within the web app running on the "Reports Module," and this selection is made for data presentation and report generation.

The system will activate deterrence and stop the turbine in real-time, regardless of the bird species.

## 5.11.2 Declaration of Species

To enable species recognition, it is necessary to declare them first in the database. This can be done by going to "Admin>Flight Types" and declaring them there. If you do not have access to Admin, please contact our technicians at info@artificialvision.es to enable this option.

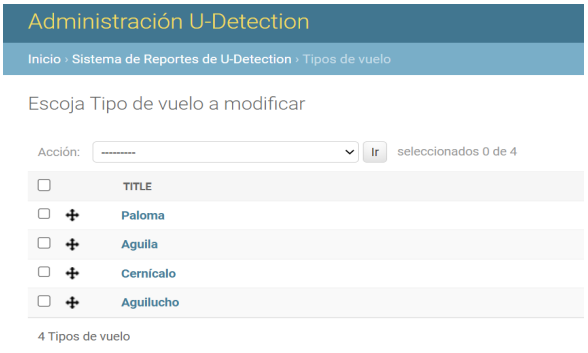


*Figure 43: Admin>Flight Types*

### 5.11.3 Manual Selection vs Automatic Selection

Initially, the system treats all flights equally and does not automatically select the species type as it has not yet learned from existing data. Once a sufficient number of specimens of each species have been selected, the system will automatically classify the following flights where the same species appears.

### 5.11.4 Assigning Flight Type to a Specific Flight

To assign a flight type to a specific flight, simply click on "Change Category," as shown in the figure below. As soon as a flight type is clicked from the options shown in "Change Category," the changes will be made without any additional confirmation from the user.

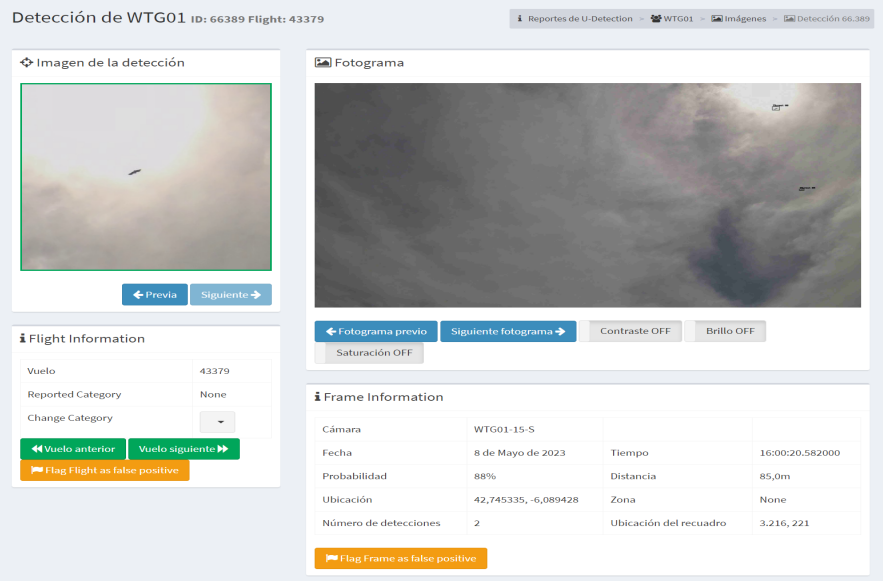



*Figure 44: Assign Flight Type*

### 5.11.5 Filtering by Flight Type

When selecting the time interval from which to obtain images, it is possible to filter the result and show only flights belonging to a particular type, as shown in the figure below.

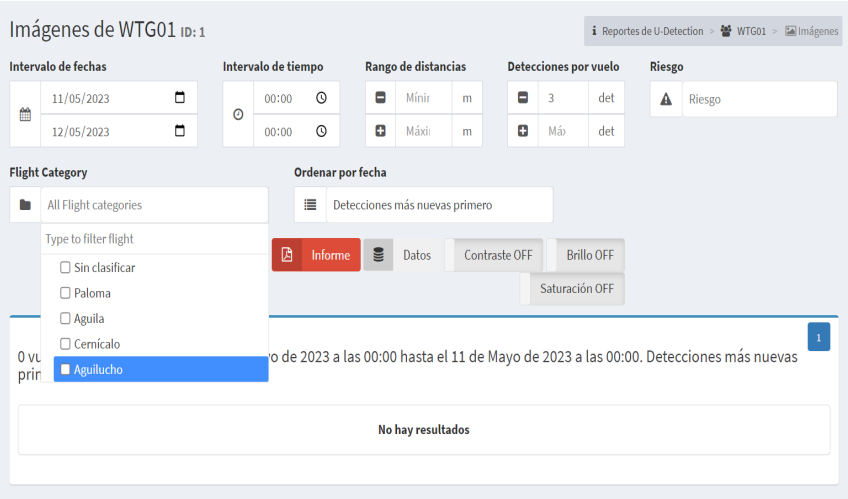



*Figure 45: Filter Flight Type*

# 5.12 Communication Monitoring System

## 5.12.1 Introduction:

The Communication Monitoring System is designed to periodically check the communication status of all the equipment and report the results to users for ensuring proper functioning.

The system aims to monitor the connectivity of the Detection Module (housed in WTGs turbines) and the Stop Module.

## 5.12.2 Communication Testing:

The Reports Module computer automatically attempts to establish communication every hour with the equipment.

The test results are published on the "Communications" section of the web application.

### 5.12.2.1 Tables:

Two tables are published in the web application:

- **"Last Communications"** table reports the result of the latest communication attempt with the equipment.
- **"Last Successful Communications"** table reports the last successful communication time with each equipment.

Last Communication

| WTG | Computer IP | Status | Last communication [UTC]) | Error | Time [H:M:S] | Id |
|---|---|---|---|---|---|---|
| WTG-01 | 192.168.10.10 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 712 |
| WTG-02 | 192.168.10.20 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 713 |
| WTG-03 | 192.168.10.30 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 714 |
| WTG-04 | 192.168.10.40 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 715 |
| WTG-05 | 192.168.10.50 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 716 |
| WTG-06 | 192.168.10.60 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 717 |
| WTG-07 | 192.168.10.70 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 718 |
| WTG-08 | 192.168.10.80 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 719 |
| WTG-09 | 192.168.10.90 | | 11 de Mayo de 2023 a las 15:00 | 0 | 0:07:22 | 720 |

*Figure 46: Last Communication Table*

### 5.12.2.2 Columns:

The tables have the following columns:

- **WTG**: Name of the turbine or computer.
- **Computer IP**: IP address of the computer to which the connection is attempted.

- **Status**: Displays a green or red icon based on the success or failure of the communication attempt.
- **Communications [UTC]**: Date of the test.
- **Error: Code** returned when attempting to establish communication. 0 indicates successful communication.
- **Time [H:M:S]:** Time elapsed since the connection attempt was made.
- **Id**: Internal identifier.

### 5.12.3 Email Notification:

If the time since the last successful connection is greater than a predefined number of hours (default is 48 hours), the system will send an email notification to a pre-defined list of email addresses. If you wish to add any new email addresses to the list, please contact our technical team at *info@artificialvision.es*.

## 5.13 Stop Time Summary

This window can be accessed from the main menu by clicking on the "Stop Time" icon.

The "Stop Time Summary" window provides a summary of the total time during which the installed systems in the park have detected avifauna near the WTGs at different levels of criticality: normal, warning, and danger.

This is an advanced user window that allows for optimizing the relationship between turbine downtime and the resulting production loss. Understanding this window is not essential for regular users.

By utilizing the information displayed in this screen, our technicians can optimize the stop and deterrence parameters of the system.

Users can select the maximum and minimum dates for the data loaded in the tables by changing the dates in their respective fields and clicking the "View" button.

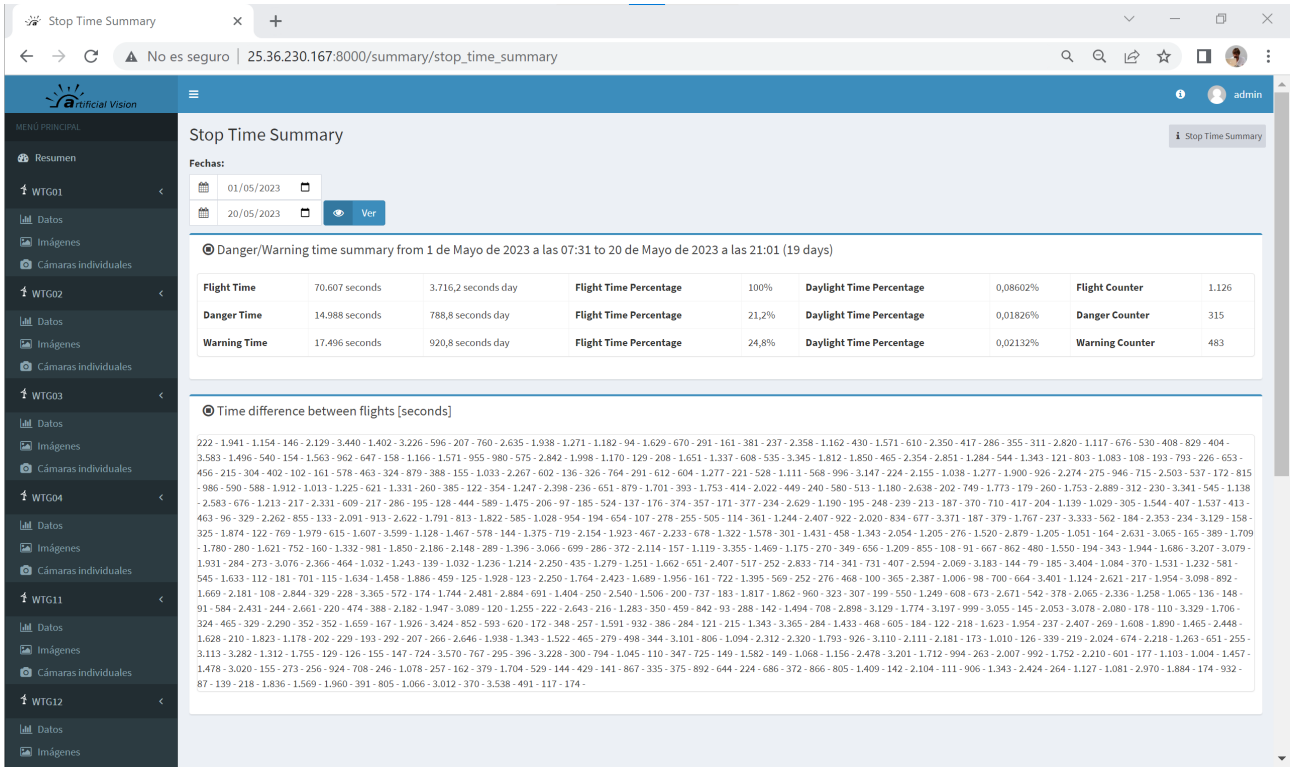



*Figure 47: Stop Time Summary Window*

### 5.13.1 Table "Danger/Warning time summary from XXX to XXX (N days)"

This table calculates the following data for normal, warning, and dangerous flights:

- **Flight Time:** The total time during which the WTGs have detected avifauna, expressed in both total seconds and seconds per day.
- **Flight Time Percentage:** The percentage of time it represents relative to the total time.
- **Daylight Time Percentage:** The percentage of daylight hours during which at least one of the turbines has been stopped.
- **Flight Counter:** A counter indicating the total number of flights.

### 5.13.2 Table "Time difference between flights [seconds]"

This table displays the elapsed times between flights expressed in seconds. Times exceeding one hour are excluded from this table.

## 5.14 Forecast Window

Using historical weather data and recorded flight activity, the system automatically retrains an artificial intelligence model every night. This model generates a forecast of bird flights for the upcoming week, including predictions of peak activity hours.

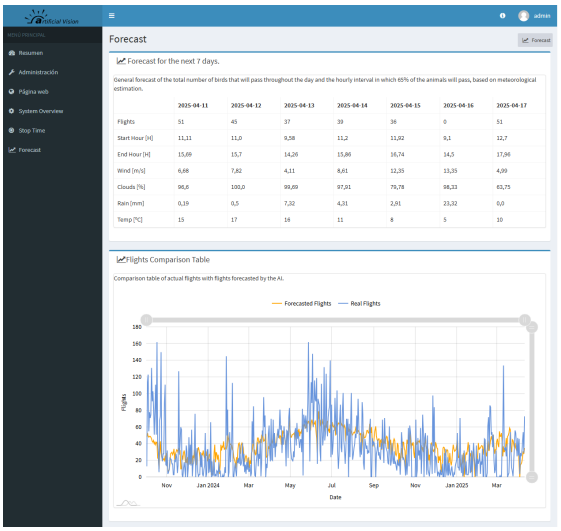



*Figure 48: Forecast & flights activity windows*

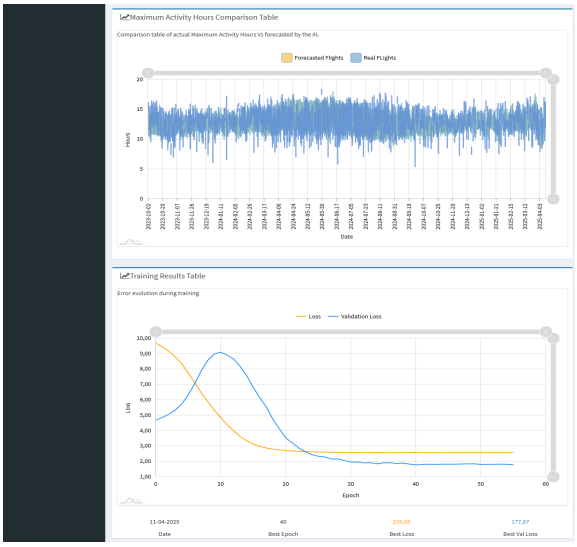



*Figure 49: Forecast & flights activity windows*

The training curve of the model should resemble the example shown in the figure. If the curve does not follow this expected pattern, it may indicate that the dataset is not yet reliable enough and additional days of data collection are needed to improve accuracy.

If you have any questions or concerns, please contact **info@artificialvision.es**.

### 5.14.1 System Overview

Every day, the reporting module automatically queries all turbines and compiles a summary of the system's performance. This overview includes the communication quality with each turbine, the number of operational cameras, the GPU usage of the AI models, and the current processing load on each unit. It also reports the software versions and the versions of the AI networks used for detection and classification, as well as the available hard disk space on each system.

This information is automatically sent each day to a predefined user email address, ensuring full visibility of the system's health and performance across the entire deployment.

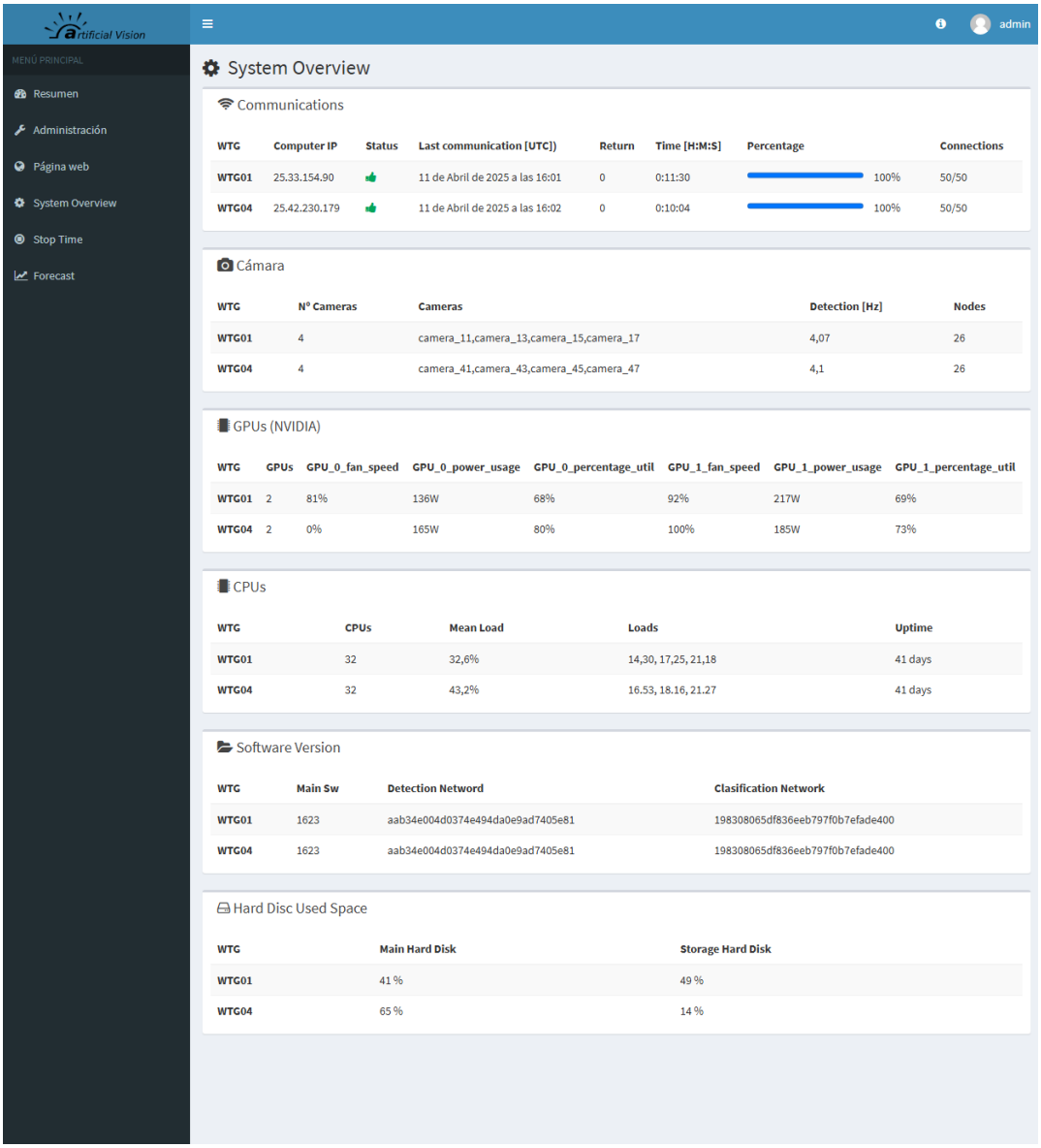



*Figure 50: System Overview*

# 6 API for Bird Detection Data

## 6.1 Introduction:

The Bird Detection System includes a robust API that allows users to retrieve bird detection data from the system. This API provides flexibility in querying data based on specific parameters such as date ranges, minimum detection thresholds, and more. The API can be accessed using the same URL structure as the web interface, offering seamless integration with other systems.

## 6.2 API Usage

To retrieve the most recent bird detections for a specific group, use the following endpoint:

*http://<computer_ip>:8000/api/group/<group_id>/images*

This returns all bird detections from the current day. However, you can also filter the results by date range and other parameters.

## 6.3 Filtering by Date Range

To filter detections by date, use the `min_date` and `max_date` parameters in the URL. The dates should be provided in ISO 8601 format.

Example URL to retrieve detections for January 1, 2025:

*http://<computer_ip>:8000/api/group/<group_id>/images?flight_min_detections=3&min_date=2024-12-31T23%3A00%3A00.000Z&max_date=2025-01-01T23%3A00%3A00.000Z*

## 6.4 API Response Format

The API will return the data in JSON format, containing a list of detections. Each detection includes key information such as:

- **id**: Unique identifier for the detection.
- **datetime**: Date and time of the detection.
- **location**: Geographical coordinates of the detection (latitude and longitude).
- **riskiness**: The risk level classification of the detection (e.g., NORMAL, DANGEROUS).
- **flight_id**: The associated flight identifier.
- **altitude**: The bird's altitude during the detection.

Example JSON response:


```
{
  "detections": [
    {
      "id": 295967,
      "datetime": "2025-01-08T15:48:22.200Z",
      "type": null,
      "frame_id": 151025238,
      "file_id": 151025247,
      "probability": 91,
      "distance": 86.0,
      "location": {"lat": 41.003288, "lon": -1.056828},
      "azimuth": 212.33,
      "riskiness": "NORMAL",
      "flight_id": 53527,
      "altitude": -4.57
    },
    {
      "id": 295969,
      "datetime": "2025-01-08T15:48:26.183Z",
      "type": null,
      "frame_id": 151025248,
      "file_id": 151025250,
      "probability": 82,
      "distance": 119.0,
      "location": {"lat": 41.002876, "lon": -1.056483},
      "azimuth": 188.29,
      "riskiness": "DANGEROUS",
      "flight_id": 53527,
      "altitude": 11.14
    }
  ]
}
```

# 7 Preventive and Corrective measures

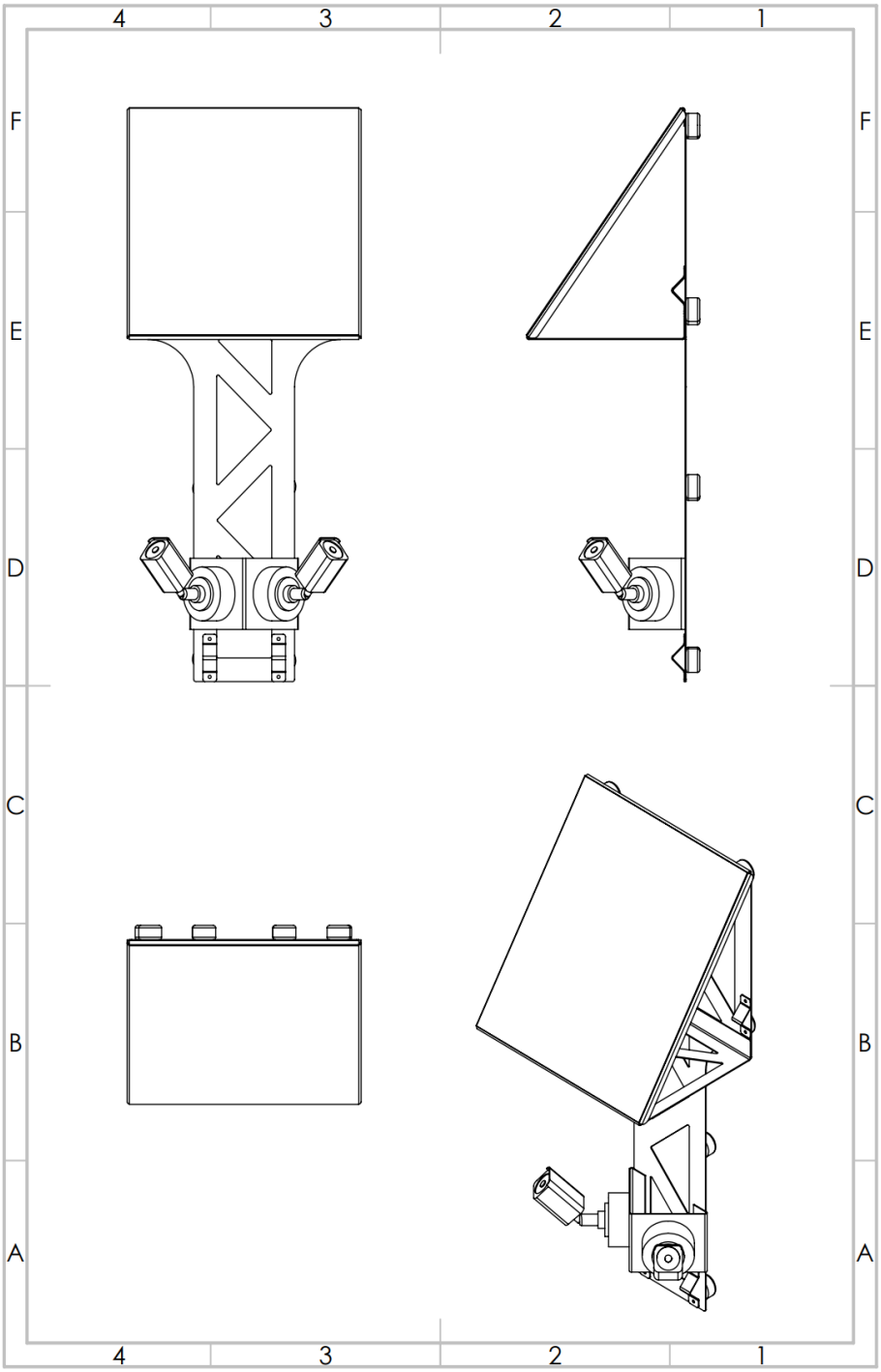
To minimize bird mortality in wind turbines (WTG), we implement both preventive and corrective measures. Corrective measures, which have been utilized for years, involve reacting actively when a bird is detected near the turbine. Essentially, two actions are taken: commanding speakers to emit high-intensity sounds simulating a gunshot to scare away the bird, and initiating turbine shutdown when the bird approaches even closer, either through SCADA or a similar system.

However, there is a challenge with turbine blade response time to the shutdown command, which can take around 10 seconds. This is because the shutdown, designed to protect the turbine mechanisms, involves a gradual reduction in blade angle rather than an emergency stop that could potentially cause damage.

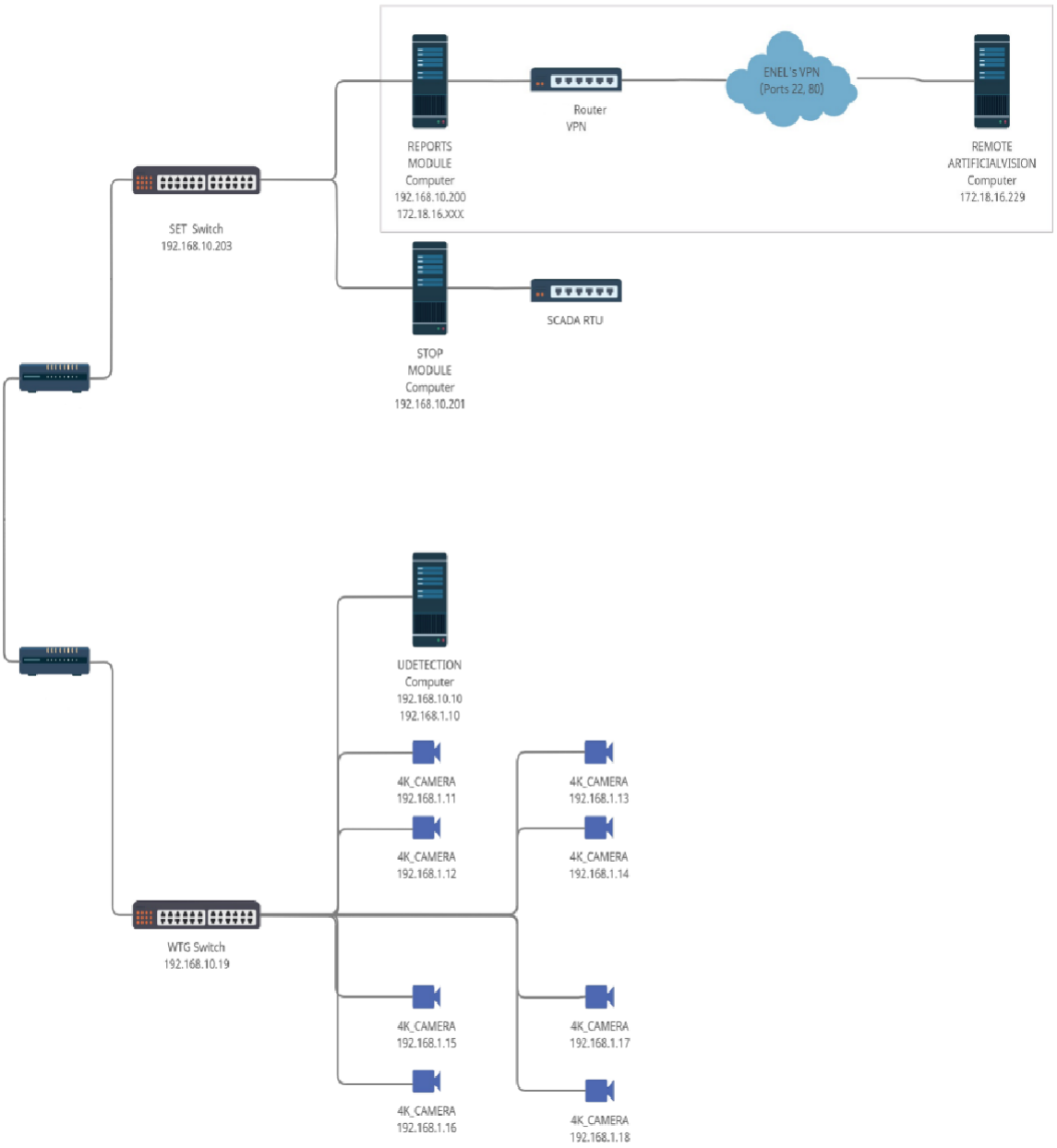
On the other hand, preventive actions are a core focus at ArtificialVision. We excel in customizing and developing neural networks to correlate historical flight activity data in any park with park meteorology. This innovative approach enables us to train a neural network capable of predicting bird activity in the field up to 7 days in advance. This foresight allows us to take proactive measures before the birds arrive and before any issues arise. For instance, we can reduce the maximum blade speed, schedule maintenance tasks, coordinate ornithologist visits to the field to enhance sighting probabilities, or even preemptively halt operations.

Our system learns and re-trains daily, continuously improving its predictive capabilities. Users can conveniently access a comprehensive report on our website, displaying both the forecasted flight activity for the next 7 days and the corresponding weather forecast. Additionally, a graphical representation showcases historical data alongside the AI-generated predictions for each day. We have achieved an excellent correlation and forecasting capability, despite the inherently wild and chaotic nature of the phenomenon we are predicting. Birds' flight patterns are influenced not only by weather conditions but also by various other factors.

# Appendix A Anti ice protection roof 3D View



# Appendix B system communications diagram



# Appendix C Changelog

This annex describes changes introduced to this document.

| Date | Changes |
|---|---|
| 2025/04/10 | • Version 1.11<br>• Added API |
| 2024/02/29 | • Version 1.10<br>• Added Forecast Window |
| 2024/01/10 | • Version 1.9<br>• Added Video Download feature |
| 2023/05/24 | • Version 1.8<br>• Added Stop Time Summary |
| 2023/05/11 | • Version 1.7<br>• Updated manual with Communication Monitoring System<br>• Added Fligth types |
| 2023/04/18 | • Version 1.6<br>• Updated manual with Stereoscopic Vision and protection anti icing roof |
| 2020/02/13 | • Version 1.5<br>• Updated cover page with greater resolution |
| 2019/11/12 | • Version 1.4<br>• Update index |
| 2019/10/12 | • Version 1.3<br>• Added more detailed steps for system operation. |
| 2019/10/04 | • Version 1.2<br>• Added new report server version. |
| 2019/07/29 | • Version 1.1.<br>• Added air-conditioned rack.<br>• Added new images of the control application.<br>• Describe the new sections of the control application.<br>• Delete in the menu the section of deterrence. |
| 2019/06/26 | • Version 1.0.<br>• Rewritten the document with new terminology included on the website<br>• Added information about rack enclosure and Detection module<br>• Added information about 4K cameras enclosure<br>• Added general configuration between modules<br>• Added Reports module information<br>• Rewritten control module and U-Detection section<br>• Added Deterrence module information<br>• Added information about mounting and measure of Deterrence module |
| 2019/03/04 | • Version of document 0.2<br>• Remove Buttons, add Menu, add modify Camera<br>• Performance Improvements |
| 2019/01/28 | • Version of document started 0.1<br>• Created Document |

If you need a previous version of documentation, please, contact us at info@artificialvision.es