DRONES4VET

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MODULE 10

TRAINING PROGRAMME

PICTURES FOR EXPERTISE

Comunidad de Madrid
Dirección General de Formación
CONSEJERÍA DE ECONOMÍA, HACIENDA Y EMPLEO

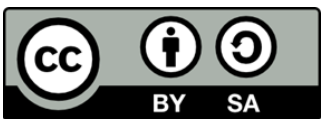
DEX
Desarrollo de Estrategias Exteriores

CAMPUS DES MÉTIERS ET DES QUALIFICATIONS D'EXCELLENCE
Habitat, énergies renouvelables et éco-construction
Occitanie

MTU
Ollscoil Teicneolaíochta na Mumhan
Munster Technological University

BZB
Bildungszentren des Baugewerbes e.V.

fh KufsteinTirol
UNIVERSITY OF APPLIED SCIENCES



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1. Objectives of the module

This module, which complements the practical flying module, gives a few tips on how to take photographs that are useful for inspecting civil engineering structures.

In this activity, unlike photogrammetry (capture is done mainly automatic), it is necessary to take "real" photos that are detailed, sharp, bright, localised and informative.

This module covers the main principles of photography, followed by advice on how to take and present photographs.

2. Camera components

A recorded image is the result of a chain of components forming the camera:

Camera = lens / diaphragm (iris) / sensor / file compression electronics / memory.

A stabilisation system adds vibration damping and even maintains horizontality. This system can be electronic (e.g. on GoPro cameras) or mechanical via a gimbal (camera built into drones such as the Anafi or Mavic), and sometimes the two systems complement each other.

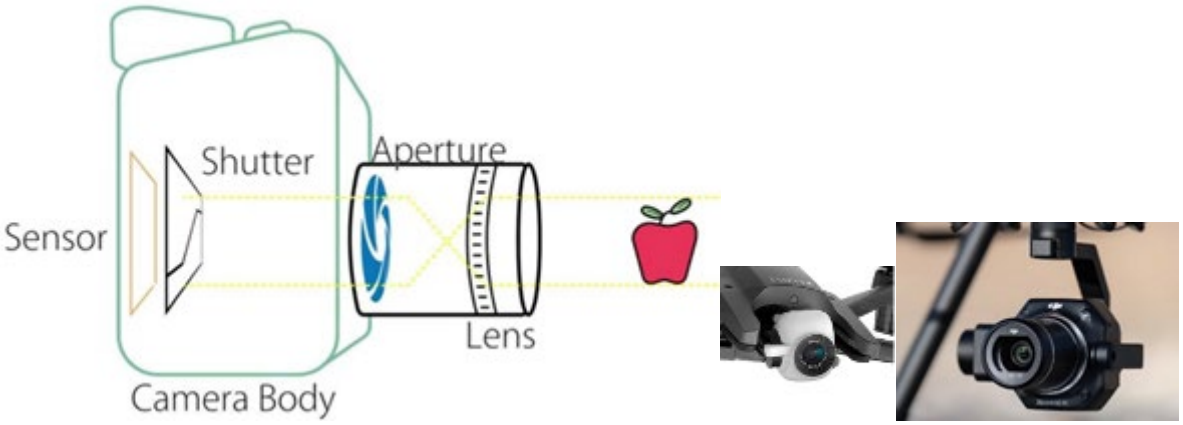

Figure 2-1 light path in camera, Parrot and Zenmuse camera (Electricalfunda) (Parrot) (Zenmuse)

2.1 Lens: precision, brightness, angle of view

Light enters the lens, which focuses the image onto the sensor.
If the lens is of poor quality, dirty or badly positioned, images will be blurred.

Characteristic: focal length (unit: mm).

A short focal length is a "wide angle" lens, which sweeps across a wide field of vision.

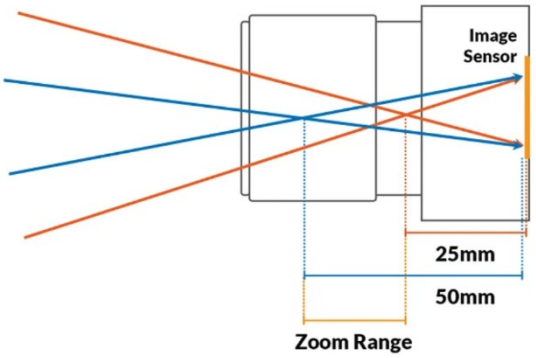

Figure 22 variable focal length

A long focal length is a telephoto lens that magnifies objects.

The focal length depends on the size of the sensor: the smaller the sensor, the shorter the focal length.

Lenses with variable focal lengths are called "zoom" lenses.

The lens is a matter for the manufacturer

the more expensive the camera, the more precise the lens, generally speaking...

the bigger the lens, the better the quality of the camera, generally speaking...

the least expensive are fixed lenses

Make sure the lens is clean before each flight.

The lens must be protected between flights by a cover.

2.2 Diaphragm or iris

At the back of the lens, a flat element forms a hole of variable diameter to let the light through, the diaphragm.

Aperture of the diaphragm: values f/2.8 to f/32 in general, f/2.8 is very open "very bright" for dark places, f/32 is very closed, for places where the light is intense.

The wider the iris can be opened, the less light is needed (small f value :)

Unfortunately, the wider the aperture, the shallower the depth of field... (see below).

2.3 Image sensor

The sensor is not adjustable in resolution, only in sensitivity.

Currently, the most interesting resolutions for our applications are at least 15 million pixels or “mega pixels” (MP), rising to over 50,000 MP (cinematographic camera). Each pixel is a point in the image; no detail smaller than a pixel can be photographed.

Sensor sensitivity (ISO from 100 to 32,000 in general) 100 is not very sensitive but very detailed because the "noise' of the sensor is very low, this noise becomes more significant higher sensitivity (above 800 ISO you can see imperfections that blur the image a little).But some high-performance sensors can withstand 12,000 iso without degrading the image too much, which is very useful indoors or in the shadow or by very cloudy days.

2.4 File compression electronics

The images are not really recorded directly pixel by pixel, they are processed to attenuate the defects of the sensors and lenses, then compressed so that the files are smaller (.jpeg or .jpg or .png format) and a slight degradation of the image follows. Good electronics and a good compression algorithm are necessary. These files are readable by all software.

To save nearly uncompressed images, there is the .tiff format, which is larger than a .jpg but more faithful in terms of resolution and colour. This file is processed to take account of the camera's characteristics.

NB: it is possible to save uncompressed, unprocessed images in RAW format (which does not have a .raw extension, but a brand-specific extension), but these files are generally only readable by the camera software, which knows the coding used.

3. Factors influencing the image

3.1 Exposure (brightness), sensor, speed, aperture

When carrying out an inspection, you need to obtain the maximum amount of detail, so the exposure and brightness of the image are very important: details will be invisible in the dark.

← even if the sky was grey this day, the crack on top of the pillar is invisible because of under-exposure... ... but the sky is perfect (and perfectly useless !)

Figure 3-1 under exposure useless for inspection

← Same picture with the good exposure, the crack is visible, not the clouds : useful for inspection !

Figure 3-2 good exposure for the inspected area

3.2 Image Sensor

The more sensitive the sensor (above 400 iso), the less light you need. In general, sensitivity is automatic and adjusts itself as best it can. In some cases, it is adjusted manually.

- Set exposure to automatic for the general case
- Avoid backlighting wherever possible
- Locate the camera's manual exposure setting on the remote control, if available.
- Before shooting, it is important to check how the photo will look on the screen, and to adjust the brightness manually.
- If it is not possible to adjust the exposure manually, move the drone and/or the camera to get the right luminosity: take very bright, unhelpful areas out of the field.

Speed: exposure time

The longer the exposure time, i.e. the longer the light is allowed to impregnate the sensor, the brighter the image will be, but the less sharp it will be because of the risk of camera shake.

Correct exposure times must be **shorter** than 1/10th of a second or 1/(focal length in mm) of a second to be more precise. Stabilizing systems can improve the result.

3.3 Sharpness, depth of field, speed

Cameras can be fixed focus or auto-focus (automatic focus) or even manual focus (rare in drones, not very useful).

Cameras without autofocus have an original 'hyperfocal' setting with a fixed aperture and a fixed focal length: the image is sharp from a distance given by the manufacturer to infinity. Only the exposure time and sensitivity are adjusted.

Depth of field: these are the distances between which images are sharp.

The more the diaphragm is open (small f:2.8 or f:4 numbers), the less this range is, which is not an advantage for our applications. It's better to have a good "depth of field" (i.e. to have enough light for the diaphragm to close).

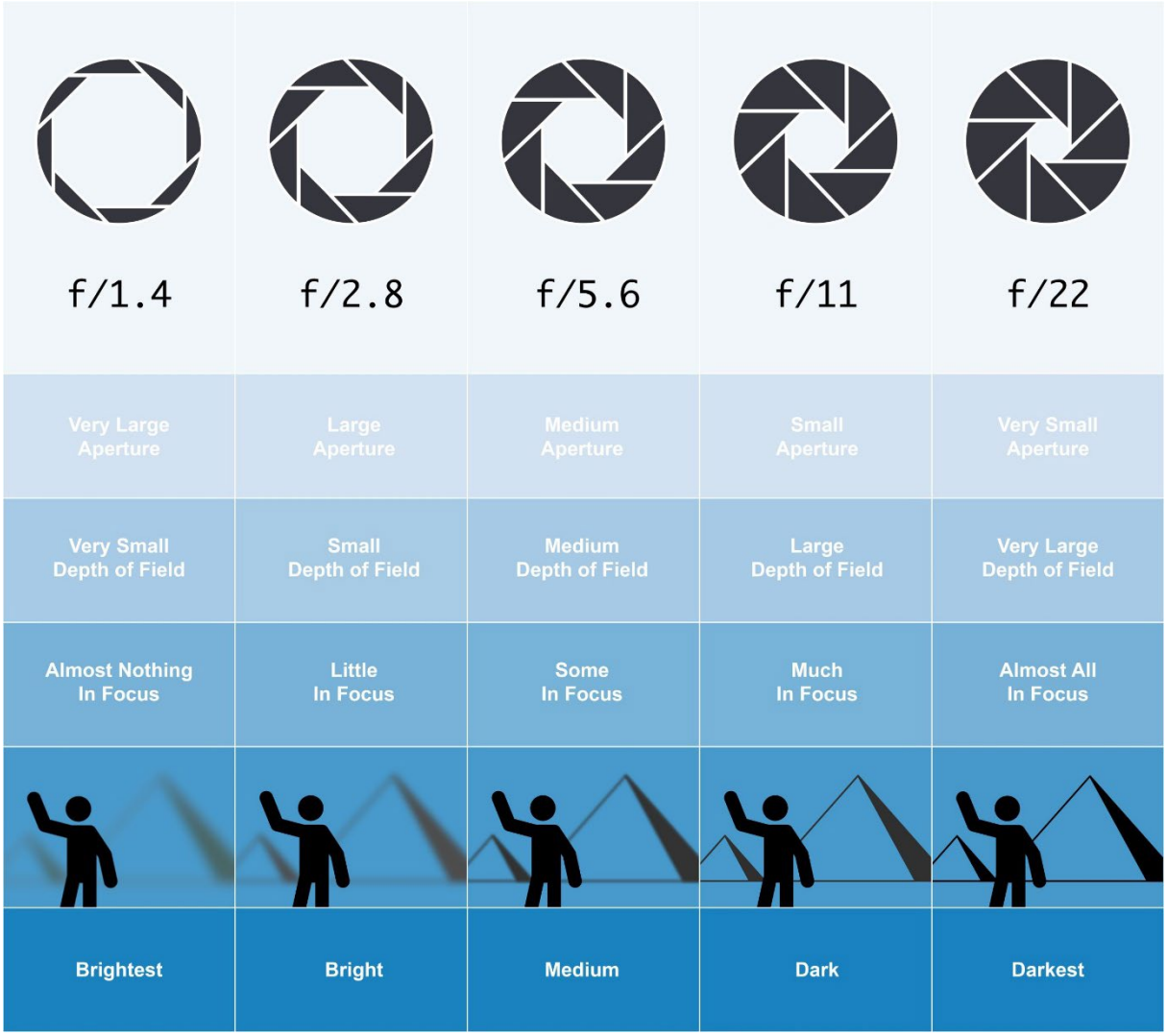

Figure 3 Effect of diaphragm on depth of field.(pressbook.cuny.edu)

The closer to objects, the more blurred the background will be if the camera is auto-focus.

Exposure time should never be less than 1/focal length in mm to avoid camera shake, but stabilisation systems can improve the result.

The sensitivity of the sensor should be as low as possible to meet all the above criteria and produce an image free from unwanted 'noise'.

Figure 3-4 motion blur

← motion blur: the drone was moving too fast, the weather was dark and the time of exposure had to be "long" .

Prefer to take your pictures while the drone is still.

3.4 White balance

Our eye automatically sets a white reference, but not an electronic sensor. When observing a white object, it is obvious to humans that it is white and the brain sets the right colour levels. Billion years evolution!

Each sensor has its own sensitivity to colour, if not corrected, then output could be incorrect.

Below is an example of different proposed settings, to the choice of the user:

Android Auto WB

Android Incandescent WB

Android Fluo 1 WB

Android Fluo 2 WB

Figure 3-5 white balance variation (Parrot)

If colour is important, a manual adjustment of the white has to be made : take a picture of a white sheet of paper on the day of the inspection in the same light conditions to perform the setting on some drones or camera.

NB: If colour is not very important, use the “automatic WB mode” it works well for most of the cases

3.5 Picture information: EXIF file

Each time an electronic image is saved, a text file is appended to it: the EXIF file, all the information are stored in this text file, access by your photo viewer ↓

[Camera] X Resolution : 72 Y Resolution : 72 Resolution unit : Inch Image description : Anafi 1.8.2 Camera Manufacturer : Parrot Camera Model : Anafi Orientation : top-left (1) Software : anafi-4k-1.8.2 Date modified : 2023:05:22 16:43:37 YCbCr Positioning : cantered (1) [Image] Exposure time [s] : 1/961 F-Number : 2.4 Exposure program : Normal (2) ISO speed rating : 130 EXIF version : 02.31 Date taken : 2023:05:22 16:43:37 Date digitized : 2023:05:22 16:43:37 Components configuration : YCbCr Shutter speed [s] : 1/961 Aperture : F2.4 Exposure bias value : 0 Metering mode : Center weight (2) Flash : No flash Focal length [mm] : 4 SubSecTime : 607 SubSecTimeOriginal : 607 SubSecTimeDigitized : 607 FlashPix Version : 01.00 Colour space : sRGB EXIF image width : 4608 EXIF image length : 3456 Focal plane X-Resolution : 1793026901/241026 Focal plane Y-Resolution : 1793026901/241026 Focal plane res. unit : cm (3) File source : DSC Scene type : A directly photographed image Exposure mode : Auto (0) White balance : Auto (0) Light source : Unknown (0)	The X an Y resolution are useless here because the 72 means "72 dot per inch" and out of context, it is just a default value. The resolution is useful only if you scan an image or print it. Type of drone and camera: here a Parrot Anafi Very important: the date and time of the picture. In expertise this can be decisive in the event of a dispute Default compression mode: The luminance (Y) is centred relatively to the Chrominance (the colours blue Cb and red Cr). If "cantered" is not written, a specific compression was applied and your picture software must handle it. The shutter was opened only 1/961 of a second (0.001 second) very fast, so no risk of blur. The diaphragm was opened to 2.4 (consider 1 is a very good luminous lens, 2.4 is good) but in wide open diaphragm like this, the depth of field is shallow. The exposure is not modified, in + or - to get more or less luminosity The sensibility of the sensor is set at a low ISO value, it is better for details and quality. On high values, more than 1000, some "noise" may appear and the picture has less details. There are some repetitions in the EXIF ... The exposure was not modified. The exposure was measured averaged over a central area of the photo. It is possible to choose "spot", a very small area, or "full" to make the average on all the frame. "Centre weight" is a good compromise. The focal length is here the real one (lower in the exif is the equivalent in 35mm camera) Milliseconds to add to the date taken : 16h 47' 37.607" time accuracy (not all cameras) Standard colouring codification Number of pixels in the X (horizontal) direction of the frame. Number of pixels in the Y (vertical) direction of the frame. It means the photo is 4608x3456 = 15.9 megapixels (the resolution of the sensor) ? DSC=digital still camera : the picture was directly recorded from a DSC, not from a scanner or else. Settings of the camera

Focal length (35mm) : 23 Scene capture type : Standard (0) Contrast : Soft (1) Saturation : Low (1) Sharpness : Soft (1) [GPS] Version ID : 2.3.0.0 Latitude Ref : North Latitude : 43° 49' 38.65" Longitude Ref : East Longitude : 4° 21' 25.04" Altitude Ref : Sea Level Altitude : 49.9667 Satellites : 14	The focal lens is here expressed in 35mm equivalent: it is useful to know that 50mm is the equivalent of the human vision for perspective. Under (for instance here 23mm) the perspective is exaggerated, things look wider, longer. Over (such as 150mm) the perspective crushes objects, making them look shorter, flat. Other settings, here on the default values, no specific correction was applied, which is better for expertise or photogrammetry. The GPS information are also recorded About elevations, here a geoid was uploaded in the drone, so it corrects the altitude to indicate them relative to sea level, our usual and legal reference. But remember that normally, without geoid grid values, the GPS can only use the ellipsoid reference, which is around 50 meters under the sea level in Europe. 14 satellites is a very good score, but we don't know if it is only the ones from the GPS system or the total for GPS + GLONAS + GALILEO + BEIDU

Figure 3-6 EXIF file of a saved electronic image

4. Flight preparation

Before any drone mission, there are few steps that should be considered:

- It is essential to have an in-depth discussion with an engineer or technician who knows the structure and will point out the most interesting locations.
- **Classify the positions** to ensure a logical flight without going backwards.
- Check whether **close-up shots are possible**, depending on the wind and the available space.
- **Warn people** in the building that an AUTHORISED drone flight is going to take place and that it is possible that it will pass close to the windows, but that interiors and faces will not be filmed or will be masked, and/or that the photos are not public and are only intended for the technical assessment of the work, in compliance with professional secrecy.
- **Mark out** the perimeter of the flight so that uninvolved persons are not present under the drone.
- Choose one or more flying positions that allow you to **see the drone at all times**, but also to get a good view of the control screen (in the shade, for example).
- Decide whether it would be a good idea to use **FPV** goggles to get a better view of the images. Note that you will need a 2nd person to keep an eye on the drone.
- Fill up the **mission sheet** and carry out the usual **pre-flight** checks and adjust your **camera**.
- Make sure to check the **weather**, because if the wind picks up, the camera will move more when it's close to the structure, and the photos may not be sharp enough. Grey days favour uniformity of light, except for the underside.
- Choose the **time of day** to ensure that the elements photographed are well lit, and/or that there is no shadow/light boundary in a picture of a point of interest.
- In the case of façade flatness surveys, prefer low-angled light to accentuate the relief.
- Suggest to the customer, for an additional charge, a **photogrammetry** of the facade or the entire structure - CAUTION: photogrammetry generally does not provide sufficient detail for an assessment of cracks or other localised damage. Software continues to improve with the power of computers, and this assertion is less and less true for those who own the visualization software, but these close-up photos are still useful for building up a record book of the evolution of a construction's problems.
- If the drone is **RTK**, don't forget to activate the connection and check.
- If possible, record in .TIFF format or the biggest .JPG possible (less compression = more details).

- If the location is dark, limit the automatic increase in **sensor sensitivity** to a value where there is not too much noise (see the manual for the maximum range and recommendations).
- Check that the **date and time** are correct throughout the system, so that the photos are correctly time-stamped. This can be very important in certain cases where there is a risk of a building rapidly falling into ruin.

5. Photo shoots

It is essential to always start by taking general views of the structure, photos that encompass the whole structure, or the whole part of the construction that is going to be inspected: this will allow to position the photo numbers close up so it is easier to locate them. If possible, take a photo from above (bearing in mind the maximum altitude of the site).

If photogrammetry has been requested, it's best to do this first as well, as it improves recognition of the structure in preparation for the expertise photos. But photogrammetry photos do not replace the large distant photo for locating expertise points. Both are required to be done.

Start the planned route and always take for each survey position :

- 1 photo large enough to be easily located on the structure
- at least 4 photos, closer and closer along one axis
- change axis and repeat this series of photos
- ... and more if necessary...

Figure 5-1large, situation photo

Figure 5-2 close-up pictures taken by approaching the drone to keep high details

Always check on the control display that the image is satisfactory.

The drone must be stationary to take the shot, not moving.

Beware of backlighting,

Beware of blurred images,

Be careful not to be in a ventilation air stream or chimney gas that is dangerous for the drone or which opacifies the lens.

Check the GNSS (and the RTK if equipped).

6. Deliverable

6.1 Processing

The customer needs to recover images that are classified, easily identifiable and perfectly usable:

First create a backup copy of all the photos...

Then create a working folder and copy all the photos into it.

View all the photos on a large screen and delete any that are blurred or unusable,

It is possible to slightly modify the brightness to improve visibility BUT NOT ANYTHING ELSE, especially not the colours or the sharpness, or the contrast, NOTHING. The customer will make his own adjustments if necessary, but must obtain photos that are as natural as possible because he can see details or nuances that you would have made disappear by processing them.

➔ Display one of the global photos of the construction in a drawing program and the local expert photos on another screen: write the numbers of the local photos in their locations on the global photo, if possible with an arrow indicating the axis of the shot. See below:

Figure 6-1 situation and numbering of sighted sites

6.2 Electronic Deliverable

Create 2 folders:

- Start: this contains the global (location) photos and the referencing document (see below) in .docx (or other) and PDF formats.
- Expertise [name of the building]: this contains all the detailed photos, which are accessed from the reference document via an external link.

Create a referencing and access document with a word processor or in html. The cover page indicates the title, the mission, address, cadastral reference, name of the customer, name of the drone operator, name of the photographer and the date on which the photos were taken. At the beginning of the document, position the global photos with the numbers of the groups of local photos (format 13x20cm for a ½ A4 or more depending on visibility). The rest of the document includes thumbnails of all the photos (3x4.5cm format for example) classified by location for identification and a hyperlink to the original photo for easy access.

The global photos must have explicit names: "global facade Nord.tiff" for example.

The access document should also be self-explanatory: "expertise 17 Dhuoda Street.docx" for example.

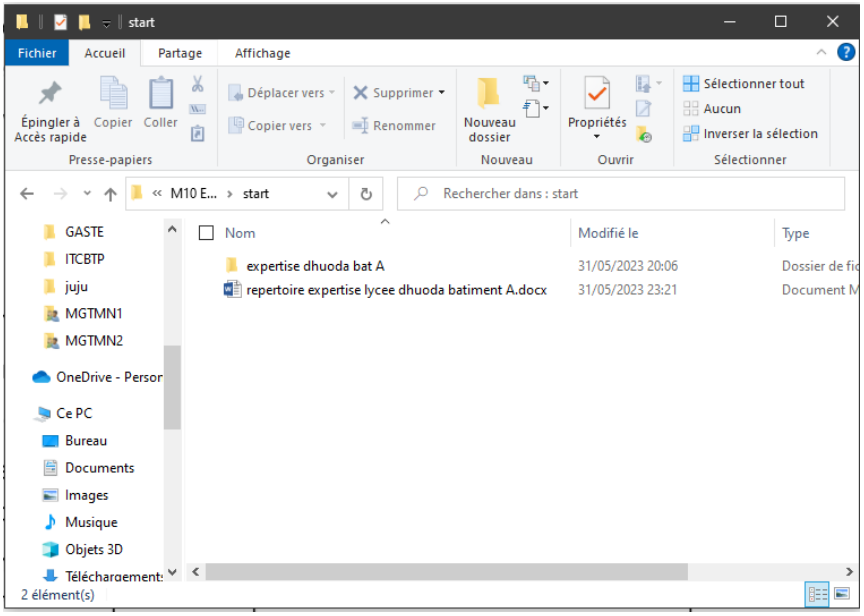

Figure 6-2 folder organisation

Create a PDF duplicate of the reference document, with links included.

Detail photos can keep their original name.

Create a new archive of these two files.

A paper printout of the reference document can be made for conventional archiving in the customer's "hanging file" folder in the old-fashioned way, to reassure the secretariat!

Next 4 pages are the copy of the original deliverable.

"LYCÉE DHUODA"
PICTURES FOR EXPERTISE

Mission : explore the South East facade of the « A » building and sight 3 places where cracks with concrete burst and defects in the waterproofing coating are detected.

Adress : 17 rue Dhuoda 30000 Nîmes, France

Cadastral reference : EW 496

Customer : Expert Gard 25 rue de la République 30000 Nîmes

Drone operator : Régis Lequeux – ExactDrone – 5 Bd Victor Hugo 34200 Sète

Date : 22/05/2023

PICTURES POSITIONNING

Next pages : reduced pictures and links to the full resolution photo files

EXPERTISE IMAGES AND LINKS TO PHOTO FILES

1 Crack and concrete burst under a beam

expertise dhuoda bat A\P1460934.JPG

expertise dhuoda bat A\P1470935.JPG

expertise dhuoda bat A\P1480936.JPG

expertise dhuoda bat A\P1490937.JPG

2 Crack and concrete burst under a slab

expertise dhuoda bat A\P1540942.JPG

expertise dhuoda bat A\P1530941.JPG

expertise dhuoda bat A\P1520940.JPG

expertise dhuoda bat A\P1510939.JPG

ExactDrone Aerial expertise
Lycée Dhuoda « A » building – concrete and waterproofing

3 Defect on waterproofing coating above the lift shaft

expertise dhuoda bat A\P1590947.JPG

expertise dhuoda bat A\P1600948.JPG

expertise dhuoda bat A\P1630951.JPG

expertise dhuoda bat A\P1640952.JPG

// expertise images lycee dhuoda building A.docx p. 4

(previous pages :)

Figure 6-3 deliverable with links to full size photos

6.3 Paper deliverable

If the customer also wants a paper edition, all the photos in the reference document must be resized so that they are no longer thumbnails but "correct" format photos (10x15cm for example), leaving space underneath and on the sides for the customer to write comments, add annotations, etc.

Print on fairly thick paper (at least 120g/m²). Photo paper is not essential unless specified in the contract (and the price!). Do not print on an office printer, especially not an inkjet printer, and leave the job to a professional if you do not have sufficient quality colour laser at the office. You will then have to save the document as a PDF.

Have an extra copy printed for archiving at the office.

Computer archiving is also essential.

List of figures