IPACO expert report

Expert name	*Report date*	*Last update*
Antoine COUSYN	December 28, 2016	

Type	*Class*	*Explanation*	*Complement*
IFO	**B**	Probable child's helium balloon(s)	

Document	*Shoot place*	*Shoot date*
Photo	Buenos Aires (Argentina)	October 09, 2016, 16h06'52'' Local time

I. Imaging circumstances

This picture was shot in October 2016, in the “Aerodromo Ildefonso Durana” (Buenos Aires), by an Argentinian professional airshow photographer, using a Nikon D810 camera with a Nikkor lens, mounted on a gimbal support on a tripod. It shows a small aircraft, as well as a small object above. The photo is one of five taken in high speed (burst mode), and the UFO is only visible in the third one, namely number “*D81_6489*”. The photographer followed the airplane in a horizontal movement.

The corresponding original NEF files were made available by the photographer Gabriel Luque and the CEFAE (Colonel Rubén Lianza).

The photographer, although he was quite familiar with usual sources of artifacts (lens flares, dew orbs, etc.), was surprised by the “UFO” observed in that picture.

II. The camera

It was a Nikon D810 of which technical characteristics are shown in details here. This camera was equipped with a AF-S NIKKOR 400mm f/2.8G ED VR auto-focus lens of which technical characteristics are shown in details here.

Nikon D810

AF-S NIKKOR 400mm f/2.8G ED VR lens

The useful technical data of the photograph, extracted from the EXIF metadata, are available under the IPACO menu “*Camera – Technical data*” and are detailed below:

- Focal length (mm): **400**

- Equivalent focal length 35mm camera (mm): **400**

- Exposure time (s): **0.0025**

- F number: **9.0**

- Speed ratings (ISO): **100**

III. Data examination and analysis

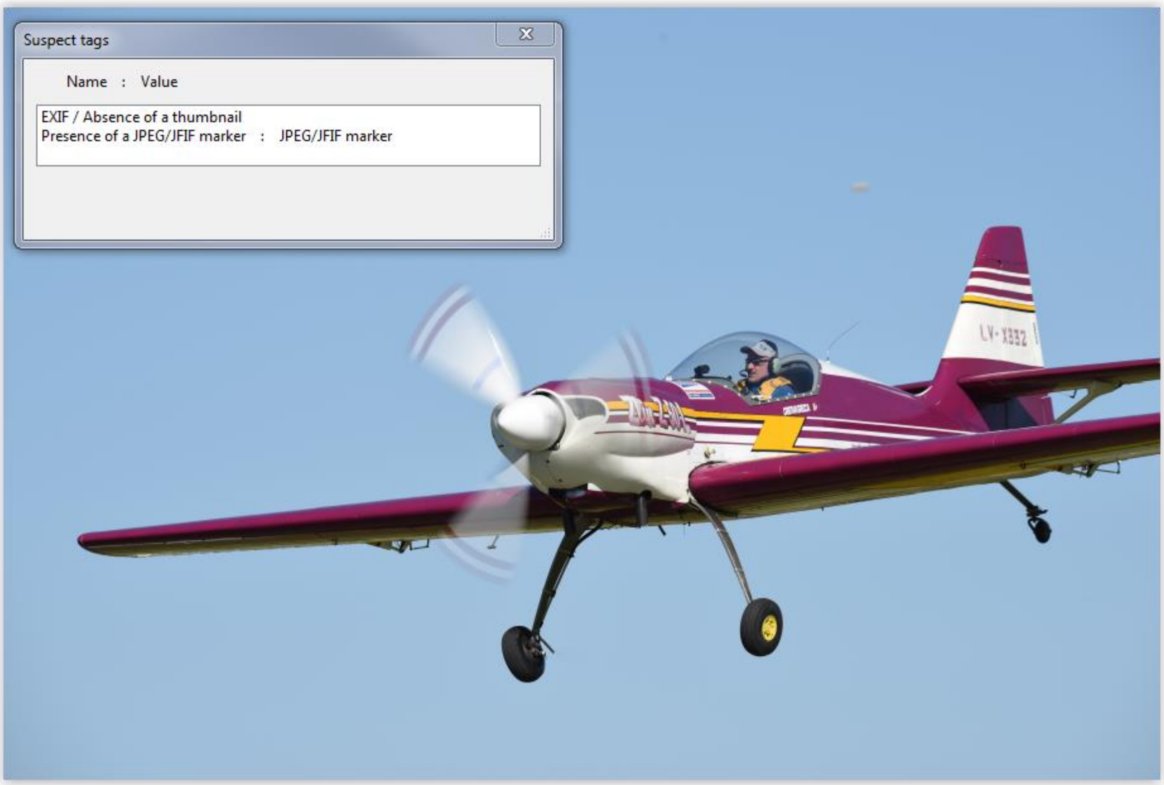
Only the original photograph n° D81_6489 with the UFO is studied in this chapter. When it is necessary to use the other photographs, they will be identified by their original names, respectively "*D81_6487*", "*D81_ 6488*", "*D81_6490*" and "*D81_6491*".

1. Authentication

Once the image is converted into a JPEG file and imported into IPACO, the first verification to do is to check if the photograph can be considered as "*original authentic*" according to IPACO's methodology definition.

This can be done by three means:

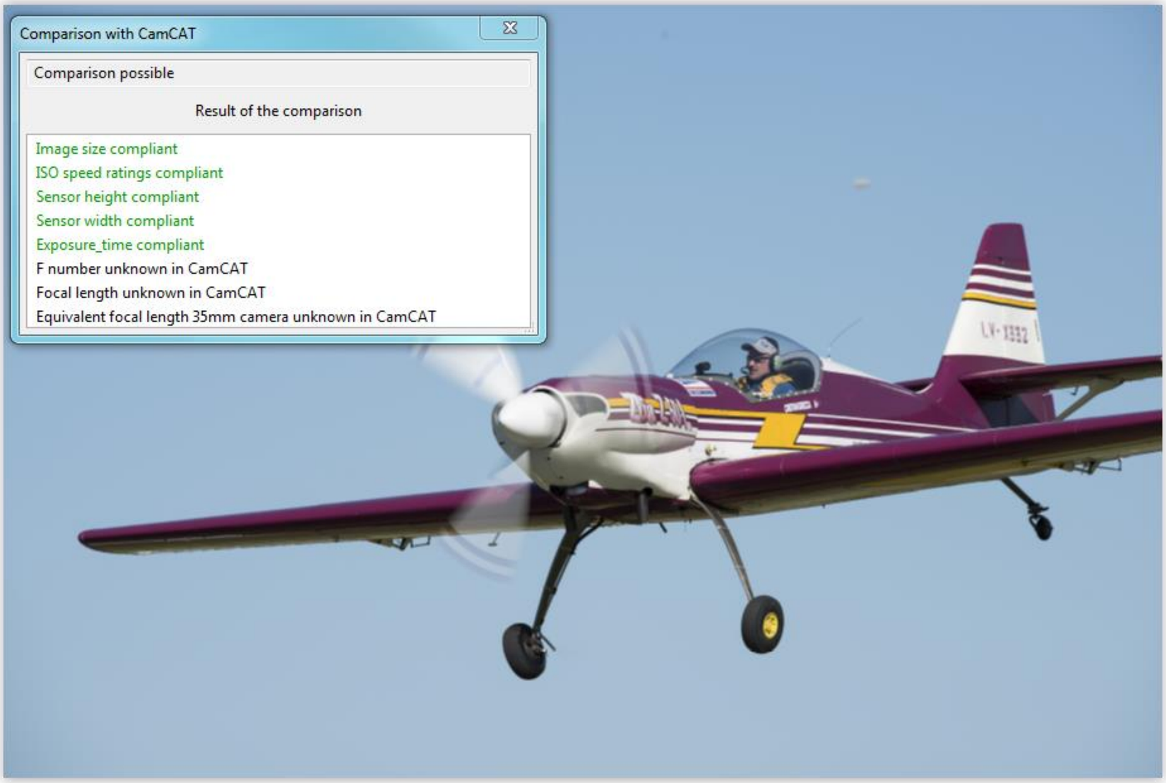
1- Using the "*Suspect tag*" function under the menu "*Authentication*":



The presence of the two lines "*EXIF / Absence of a thumbnail*" and "*Presence of a JPEG/JFIF marker*" is only the result of the conversion of the NEF file into JPEG format.

2- Using the "*Comparison with CamCAT*" tool under the menu "*Authentication*". This function is used to bring into evidence certain types of touching up in the currently displayed photo, by comparing the technical characteristics of this photo with the capabilities of the camera from which it was taken.

For instance, the size of the file is compared to the different possible output file sizes for this camera, which will show evidence of a possible cropping by a hoaxer in order to dissimulate a part of the original photograph.

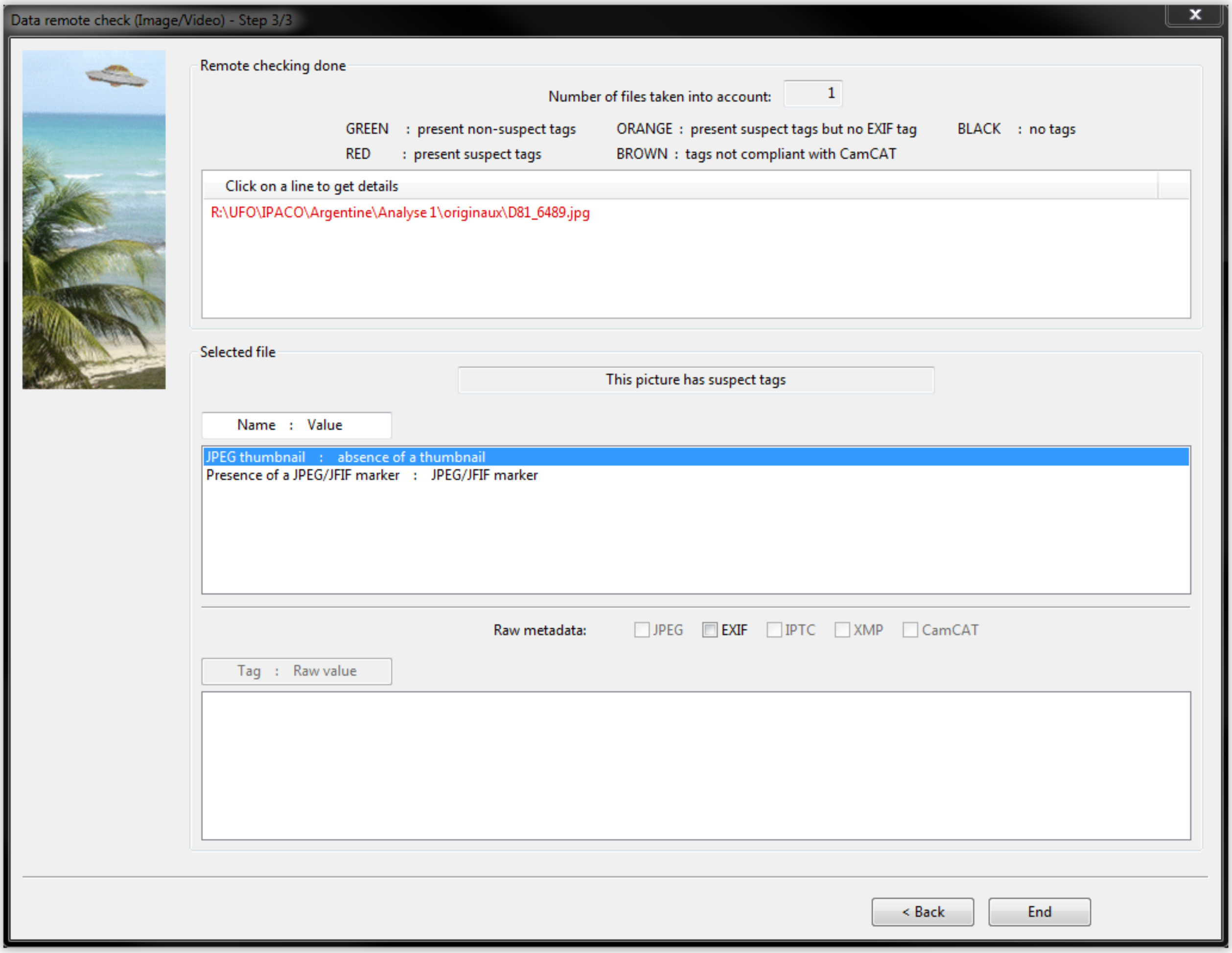


Parameters that are available in the image's technical data **and** in CamCAT appear in green if they are consistent or in red if they are not.

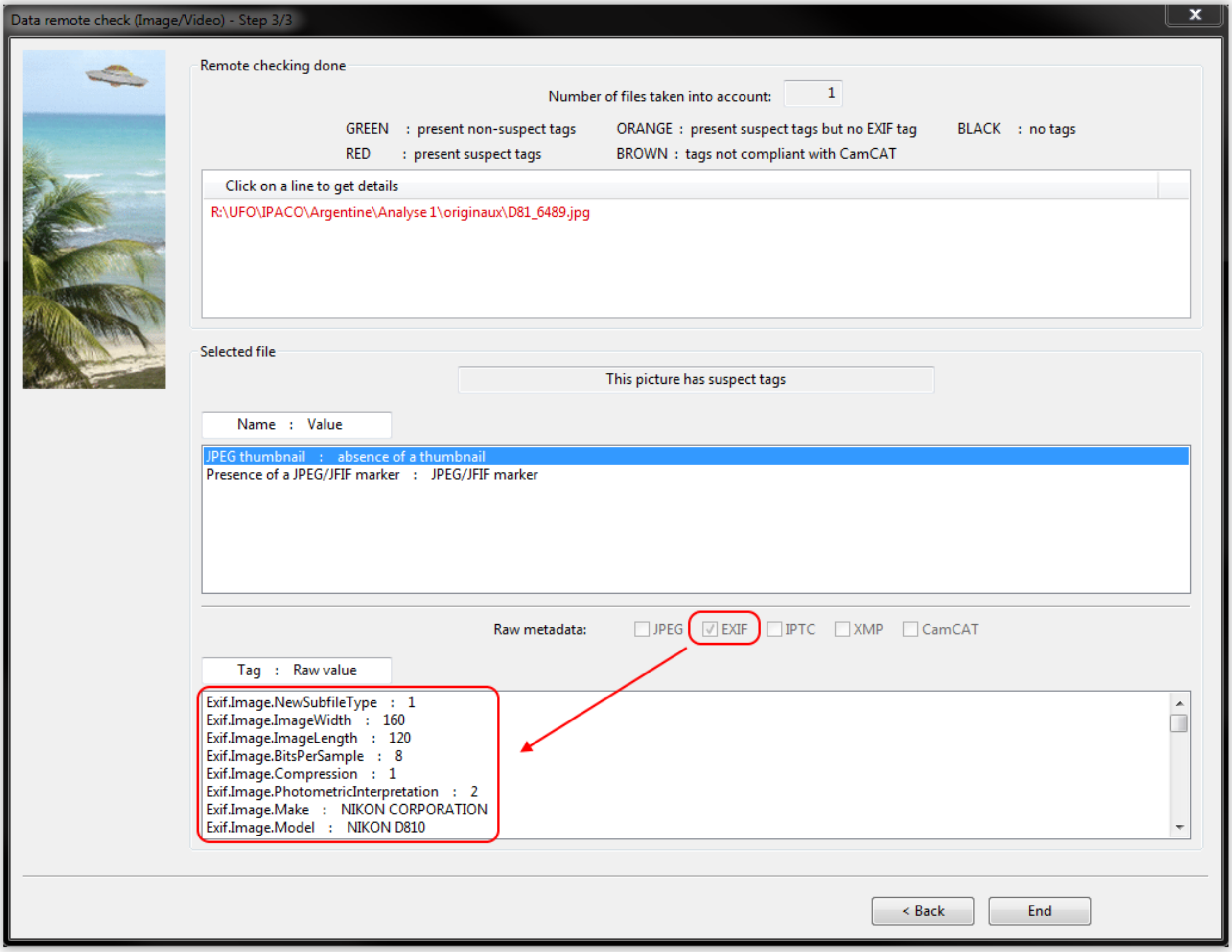
Parameters that are available in the image's technical data but **not** in CamCAT are indicated in black.

Here, all parameters are compliant with those of CamCAT, except for the F number and the focal length which are unknown in CamCAT.

3- Using the "*Remote check*" function used to quickly establish the authenticity of one or several photos present in a given folder readable by IPACO, without having to import these photos into IPACO. The principles are identical to those of the **Suspect tags** function.



As expected, the same tags with the same values as in the "*Suspect tag*" function are present. The difference lies in the lowest window where all details of the Raw metadata can be listed according to their type (JPEG, EXIF, IPTC or XMP):



EXIF tags

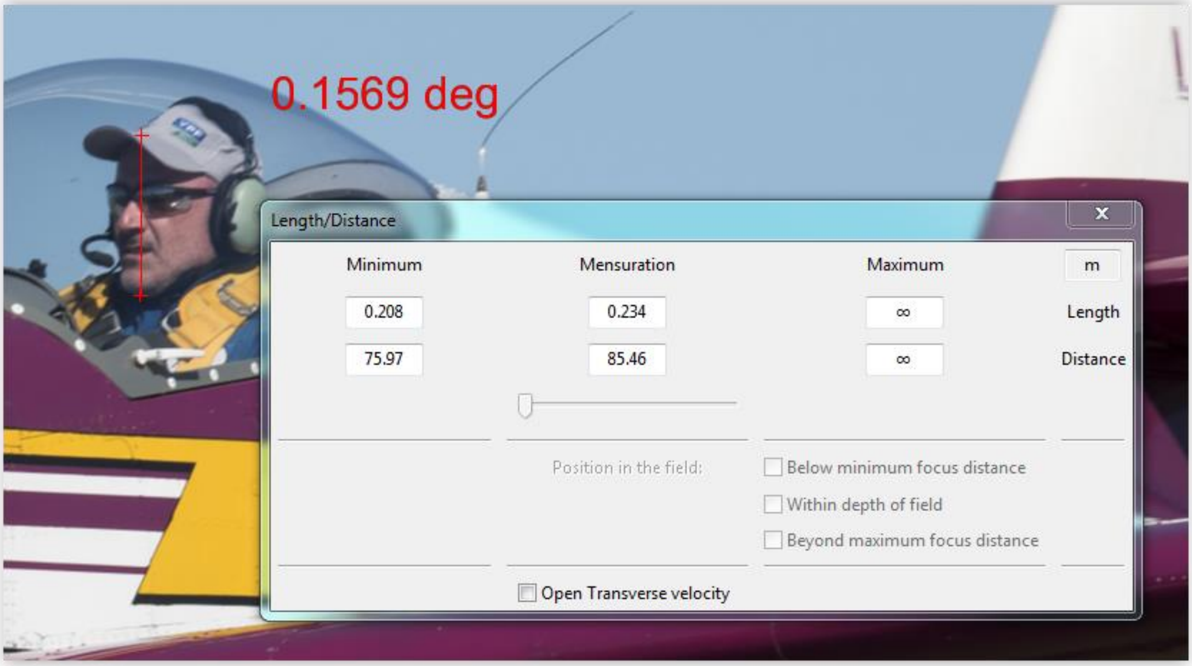
The picture can be considered as "*original authentic*", as the presence of two suspect tags is only the result of the file format conversion.

2. Aircraft's distance from the camera

This distance can be computed using the "*Mensuration – Geometric Mensuration – Length vs Distance*" tool of IPACO, knowing at first the size of one of the objects in the scene.

The pilot can clearly be seen, so we can use for example the angular size of his head, which can be measured using the "*Mensuration – Angle*" tool. It measures **0.157°**. In a human body, the proportion of the head comparatively to the complete size is of 0.13. We will take as limit sizes 1.60m and 1.80m, which gives for the size of the head a value between **20.8cm** and **23.4cm**.

Next step is to use the "*Mensuration – Geometric Mensuration – Length vs Distance*" tool of IPACO with these two values reported on the "*Length*" line. IPACO automatically computes then the corresponding distances:

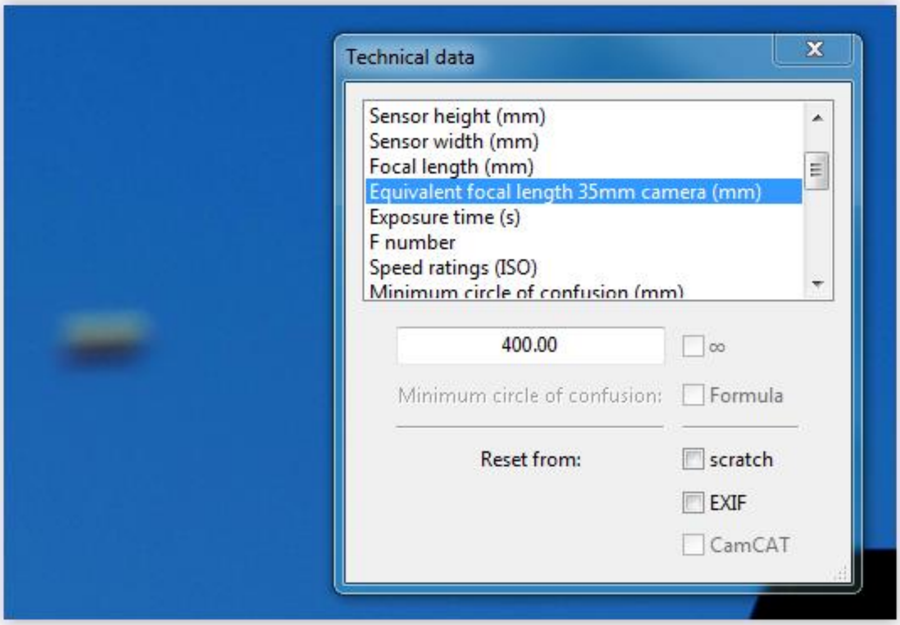


- Minimum distance (m): 75.97 rounded to **76m.**
- Maximum distance (m): 85.46 rounded to **85.5m.**

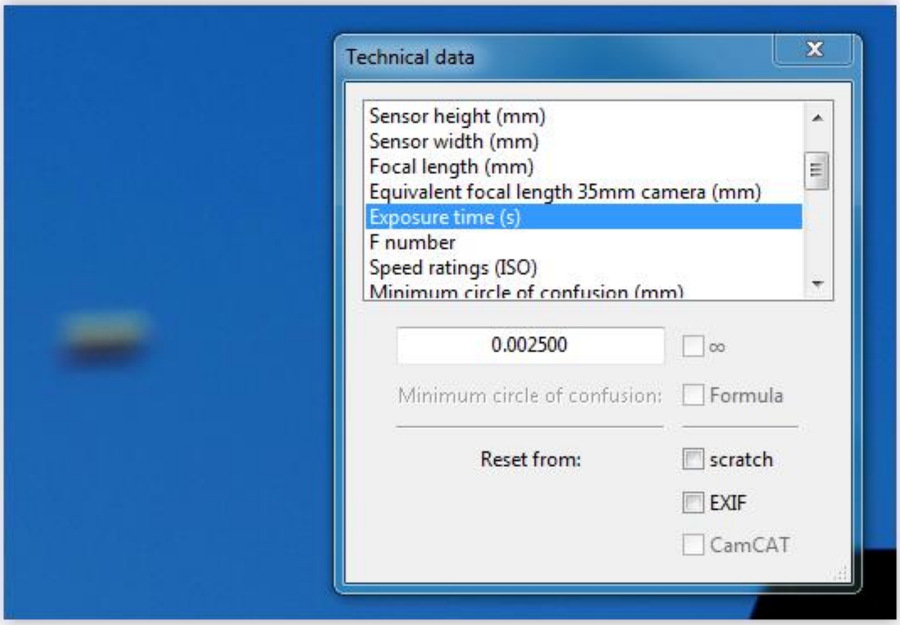
3. UFO's distance, transverse size and transverse speed estimates

The photo was taken with a Nikon D810, of which all useful technical data are available in the "*Camera - Technical data*" menu in IPACO and were already detailed above. The data of interest that are useful for the computation of possible distances, transverse sizes and transverse speeds of the UFO are the following:

- Equivalent focal length 35mm camera (mm): **400**

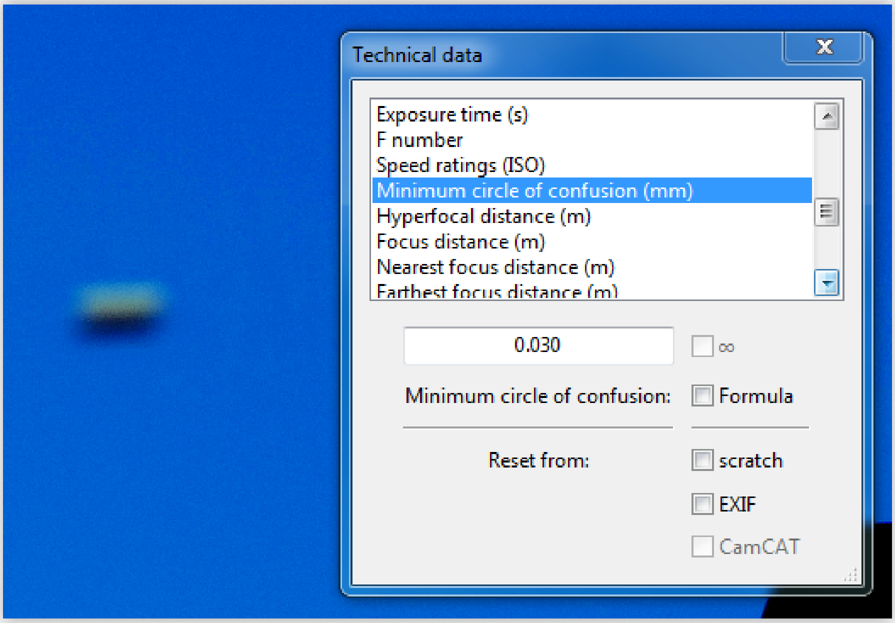


- Exposure time (s): **0.0025**



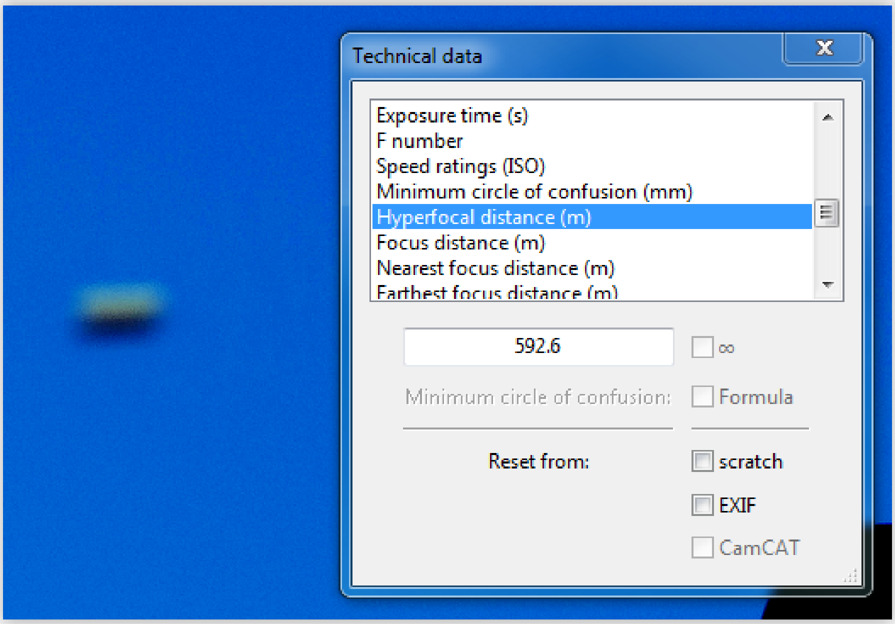
Another essential datum which is not natively present in the metadata is the "*circle of confusion*". It can however be filled manually into IPACO, since it is known from Nikon documentation.

- Minimum circle of confusion (mm): **0.03**



When the focal length, the F number and the circle of confusion are known, IPACO automatically computes the value of the hyperfocal distance.

- Hyperfocal distance (m): **592.6**



Another useful datum is the depth of field (noted hereafter "*DOF*"), which is included between the near limit of *acceptable* sharpness (defined as "*Nearest focus distance (m)*" in IPACO) and the far limit of *acceptable* sharpness (defined as "*Farthest focus distance (m)*" in IPACO). It depends on the following data, also available in the "*Camera – Technical data*" menu of IPACO:

- Minimum circle of confusion (mm): **0.03**

- F number: **9.0**

- Focal length (mm): **400**

It depends also on the **focus distance**. In this case, there are two possibilities:

1- The focus was made to infinity, with the DOF that extends from a distance to the camera shorter than that of the airplane to infinity.
2- The focus was made on the subject, with the DOF that extends from a distance to the camera shorter than that of the airplane to a distance further than this same distance.

Which one is correct?

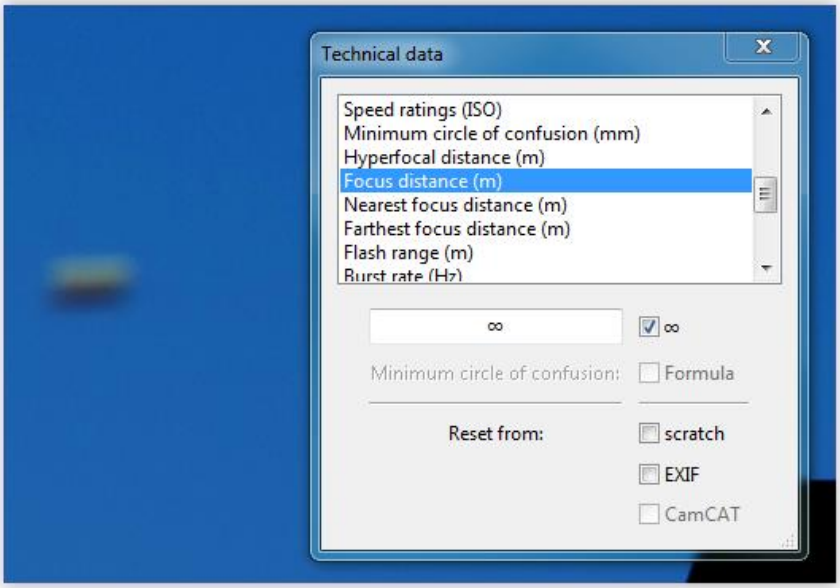
a. Determination of the focus position

As there are no reference points in the background landscape in the "UFO photo" (e.g. clouds, trees, etc.), it's impossible at first glance to say whether the focus was made to infinity or not.

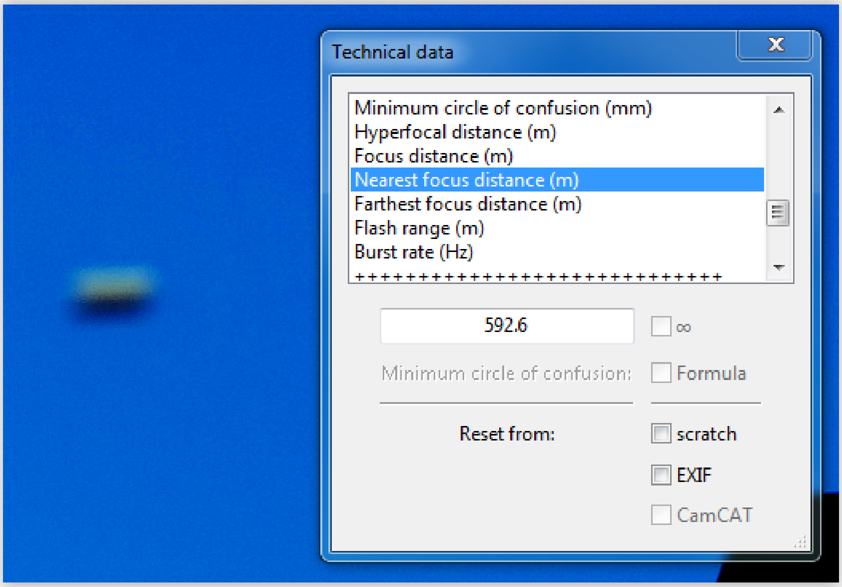
However, with IPACO, we can define both the "*Nearest focus distance (m)*" and the "*Farthest focus distance (m)*" for a given focus and see if these values comply with the above estimated distance of the airplane.

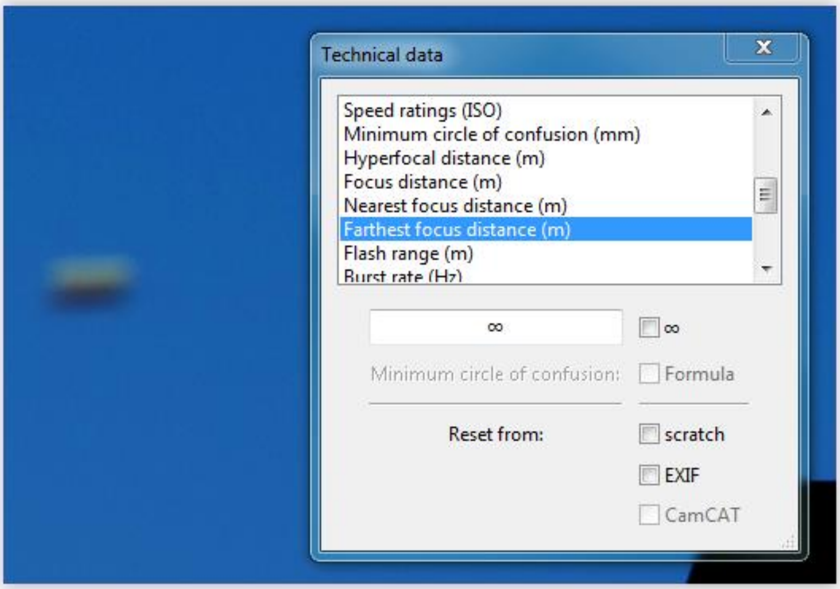
We can then check at first the results for a focus made to infinity.

In order to do this, we tick the box "∞" in "*Focus distance (m)*" in the "*Technical data*" window:



IPACO automatically then computes the two desired parameters:





As expected, the "*Nearest focus distance (m)*" corresponds to the hyperfocal distance, which is **592.6m**, meaning that everything located between the camera and this distance should be blurred.

As the airplane is *mainly* definitely sharp, it should be located within the DOF, therefore beyond this distance. However, as defined in the chapter "*Determination of subject's distance*", the airplane is located **between 76m and 85.5m** to the camera.

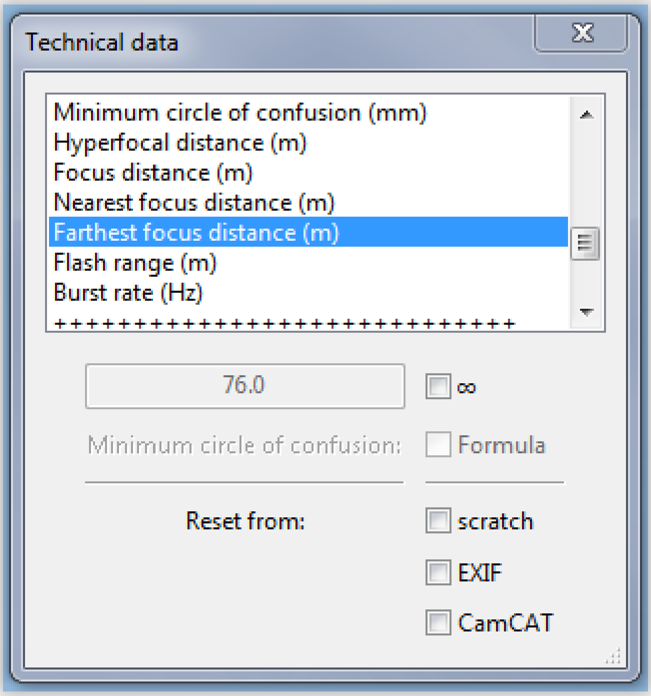
The logical conclusion is that **the focus was made on the subject**, and not to infinity.

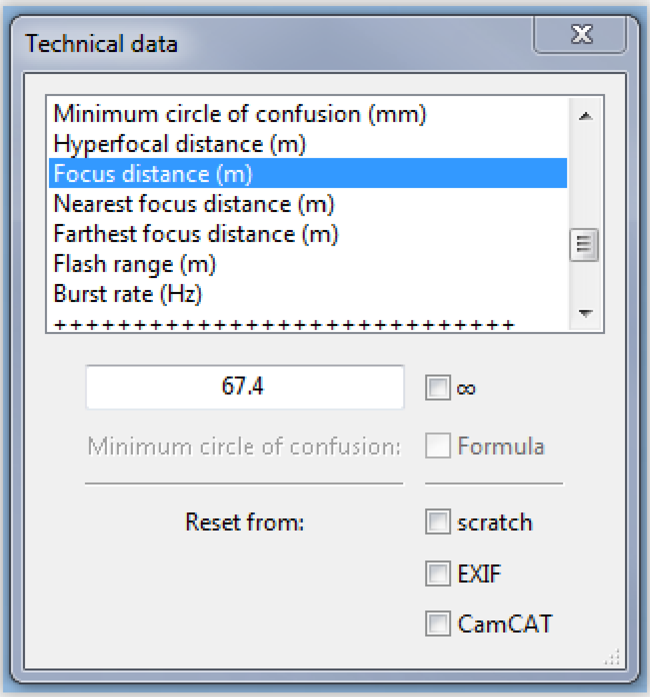
b. Determination of the possible depth of field

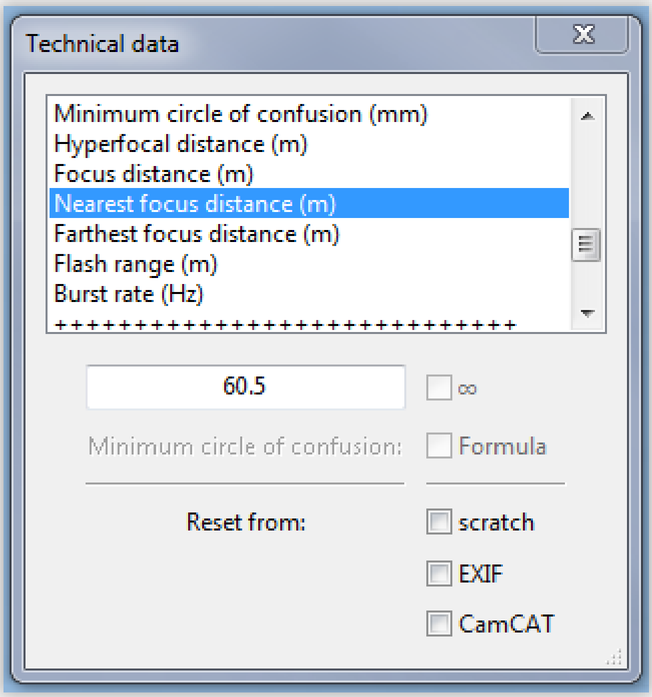
As we saw it, the focus was made on the subject, whose distance to the camera was already determined to be between 76m and 85.5m.

We next need to determine the minimum and the maximum possible focus distances to keep the airplane within the focused zone, from which we will infer the minimum and maximum distances for an object to appear in focus. This can be done in two steps:

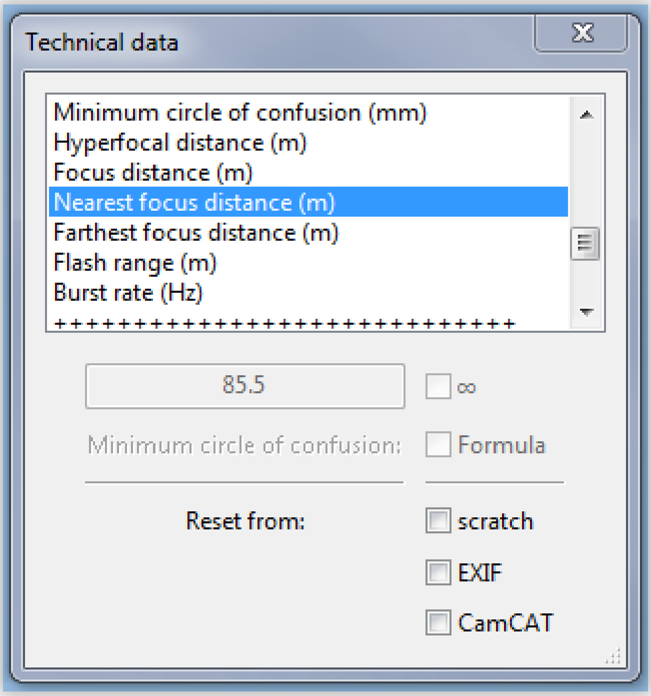
1- Input 76m in the "*Farthest focus distance (m)*" line in the "*Technical data*" box and look at the corresponding "*Focus distance (m)*" value, 67.4m, and at the corresponding "*Nearest focus distance (m)*", 60.5m:

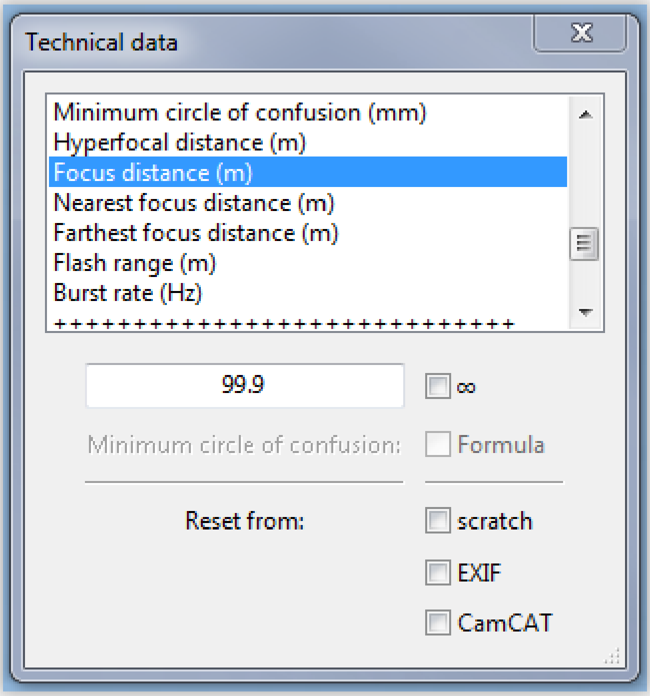


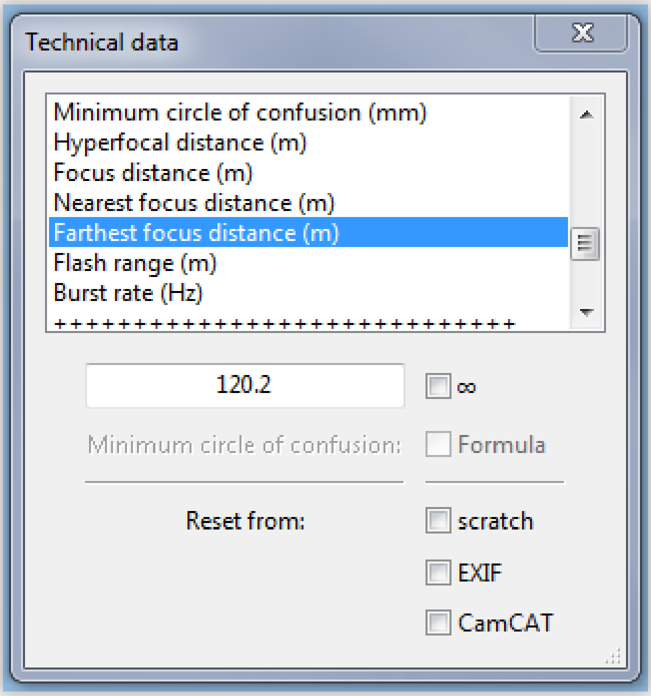




2- Input 85.5m in the "*Nearest focus distance (m)*" line in the same box as above and look at the corresponding "*Focus distance (m)*" value, 99.9m, and at the corresponding "*Farthest focus distance (m)*", 120.2m:





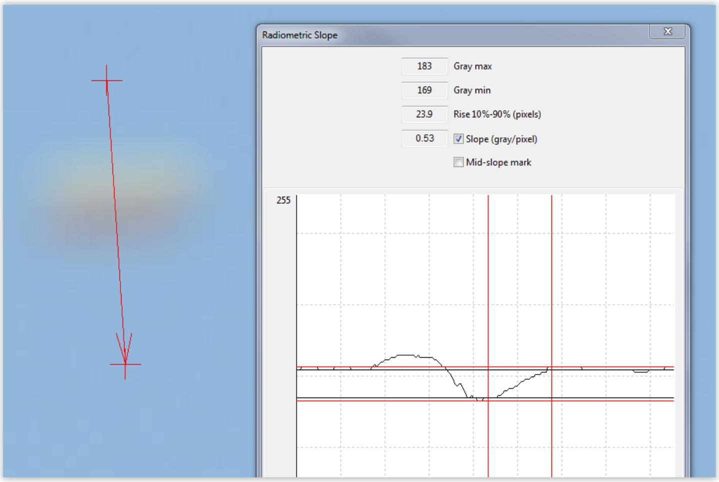


Therefore an object may have appeared in focus if its distance from the camera was **between 60.5m and 120.2m.**

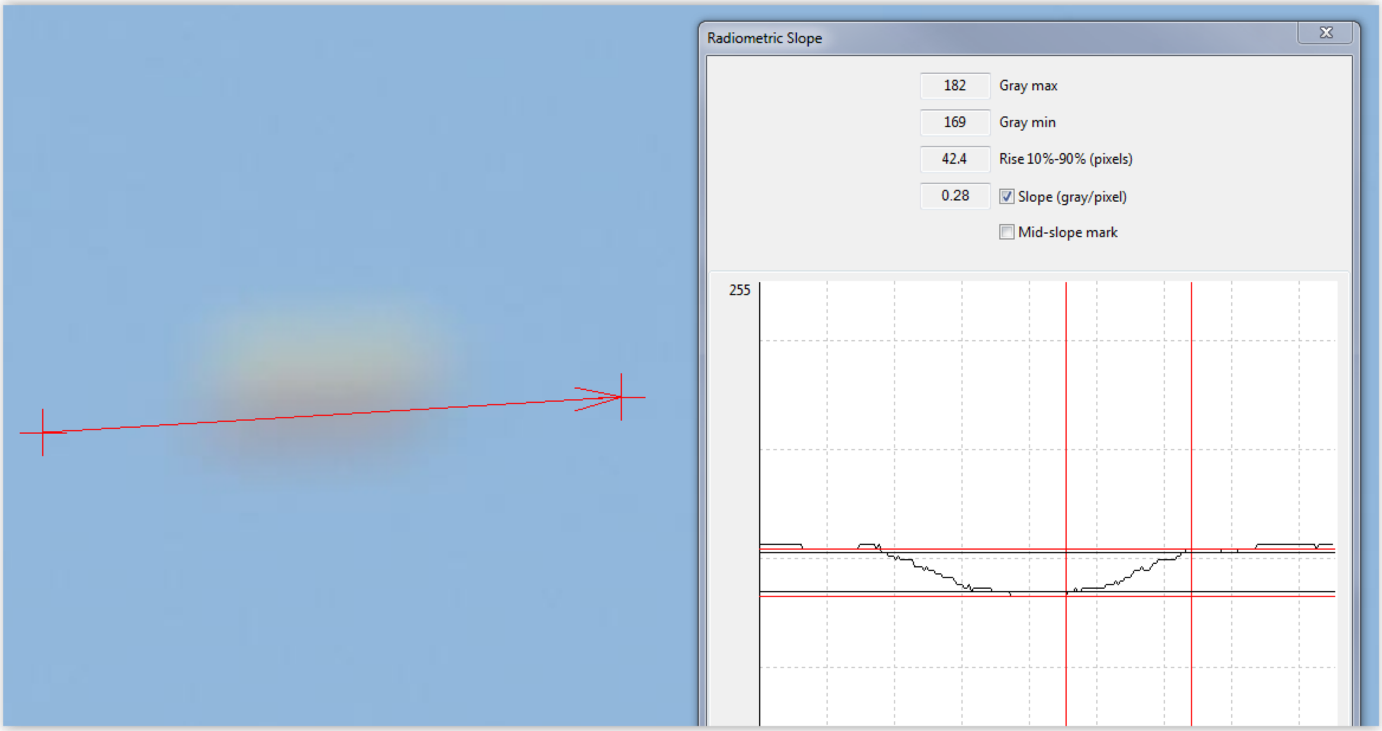
c. Quantification of the blur

The UFO appears quite blurred, in all directions.

With IPACO "*Radiometric slope*" tool, we can quantify this blur in the 2 directions of the axes of symmetry:



23.9 rise 10%-90% vertical axis



42.4 rise 10%-90% horizontal axis

There is a clear difference between the value of the radiometric slope along the vertical axis (23.9 rise) and the value along the horizontal axis (42.4 rise). This result can be interpreted as follows:

1- If the UFO is **outside the DOF**, then the blur is an omnidirectional out-of-focus blur **plus** a motion blur caused by the movement of the photographer and/or of the UFO during the exposure time.

2- If the UFO is **inside the DOF**, then the blur can be due to a combination of two movements, respectively of the photographer and of the UFO, in different directions.

Considering that:

- The photograph is one out of five taken in burst mode and that the focus cannot be changed during the burst,

- The photographer took the photos with the camera and the lens mounted on a tripod,

- He followed the airplane during these burst shoots trying to keep the same transversal speed of the camera on the tripod,

- He followed the movement of the airplane in a near horizontal way,

- On the last two photos, a blurry background landscape (trees) can be seen while the airplane is still perfectly sharp and in focus:

Photo n° D81_6490

Photo n° D81_6491

- As demonstrated in the previous chapter, the focus was not made to infinity,

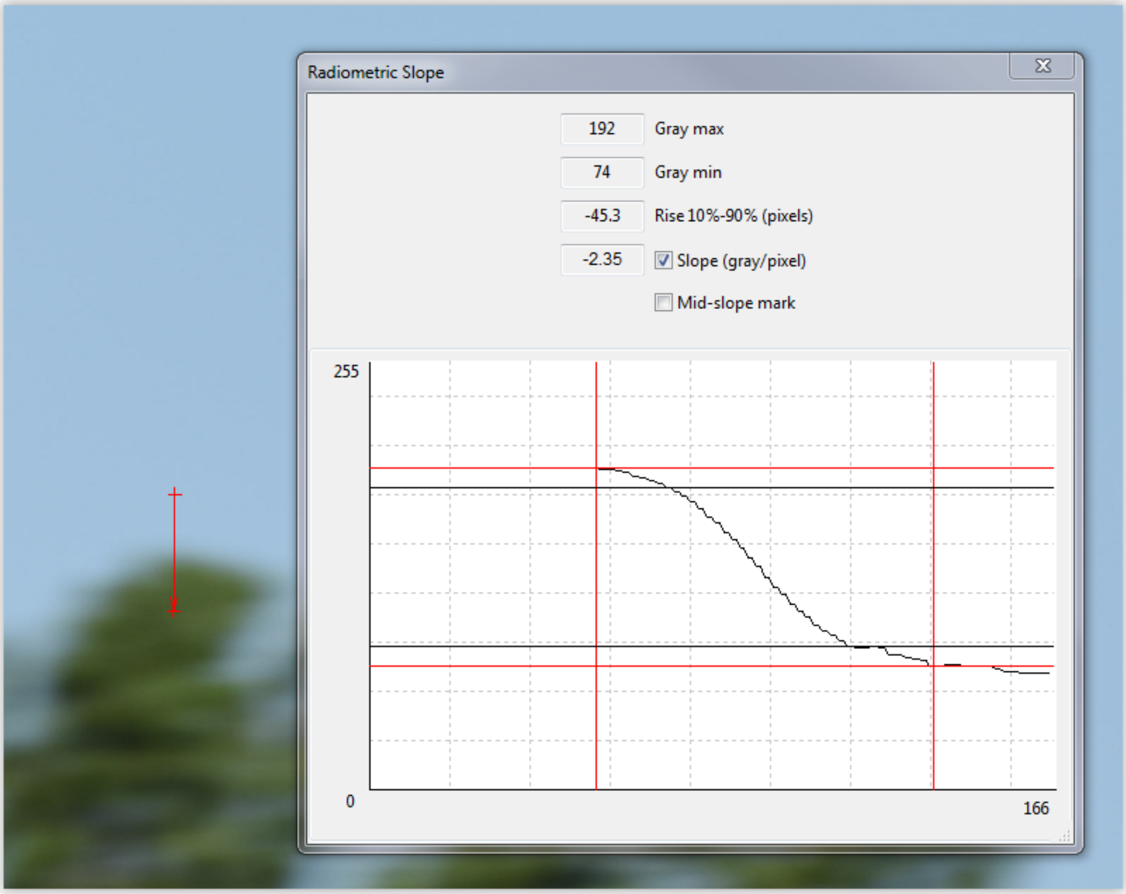
…Then **the blur of the trees** can be divided into two components:

- A nearly horizontal motion blur produced by the photographer's movement,

- An omnidirectional out-of-focus blur on the trees, which are located outside the DOF.

Therefore along the vertical axis there should be mainly an out-of-focus blur and along the horizontal axis the same out-of-focus blur plus the motion blur.

The value of the out-of-focus blur can be assessed along a vertical axis on the trees, on photo n°D81_6490, using IPACO's tool "*Radiometric Slope*":



In this sample, the absolute value of the rise is 45.3.

Ten measurements were done on various parts of the trees:

…and the median result is **43.8**.

So, using the same methodology as above, we can measure now ten radiometric slopes along horizontal axes:

The median result is **88.1**.

The "*Radiometric Slope*" function is used to estimate the sharpness of an object's edge in an image through the slope of the radiometric section along a perpendicular vector to the edge contour.

Here, it quantifies the amount of blur along the edges of the trees: the higher the value of the rise is, the more blurred the edges are.

Assuming the motion is perfectly horizontal, the median value of the horizontal motion blur alone is equal to the difference between the median value of the radiometric slopes along the horizontal axis and the median value of the radiometric slopes along the vertical axis (out-of-focus blur).

Therefore, the median value of the horizontal motion blur is equal to 88.1 - 43.8 = **44.3**.

Next step is, using the same methodology as above, to determine the median value of **the blur of the UFO** along both axes, vertical and horizontal, and to compare them to those of the trees determined above.

The goal is to try to distinguish what is the nature of the blur of the UFO and eventually if it is located inside or outside the DOF.

Ten measurements were done on the UFO on both axes and the results are the following:

- Median value of the horizontal blur: **42.5.**

- Median value of the vertical blur: **24.3.**

The value of the horizontal blur seems very close to the vertical blur of the trees, but the difference with the trees is that the UFO's angular size is small, with the same order of magnitude as the angular motion. In such a case, no comparison is possible between blurs (rises). We can only conclude that the UFO's horizontal apparent motion in the picture is larger than 42.5 and that a large part of the blur is an out-of-focus blur.

The logical conclusion is that:

- The UFO has a significant out-of-focus blur and therefore is located outside the DOF, i-e either nearer than 60.5m, or farther than 120.2 from the camera.

d. UFO's distance and transverse size* estimates

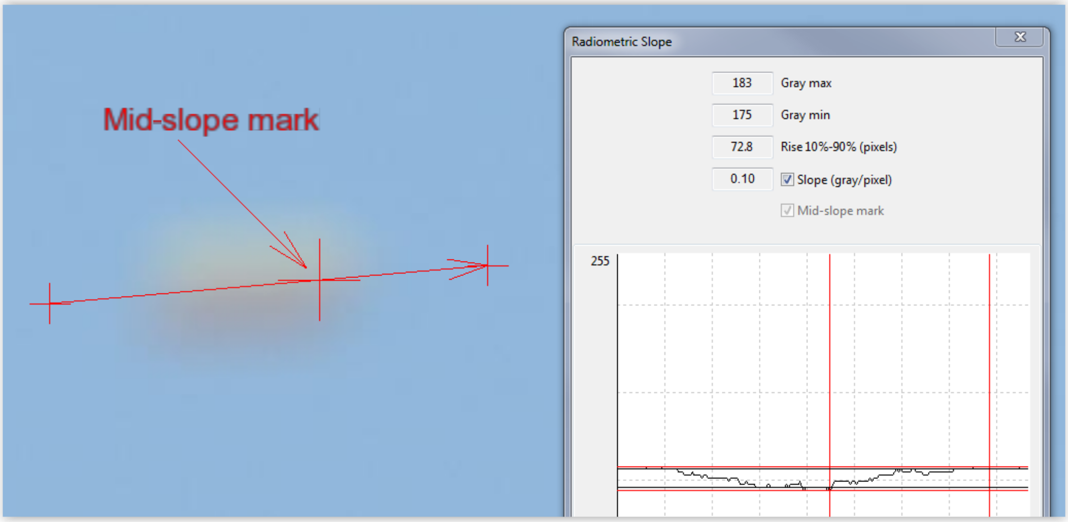
The DOF is short, somewhere within the range **from 60.5m to 120.2m**, perfect for the capture of the airplane in focus. Everything that is outside this range is out-of-focus.

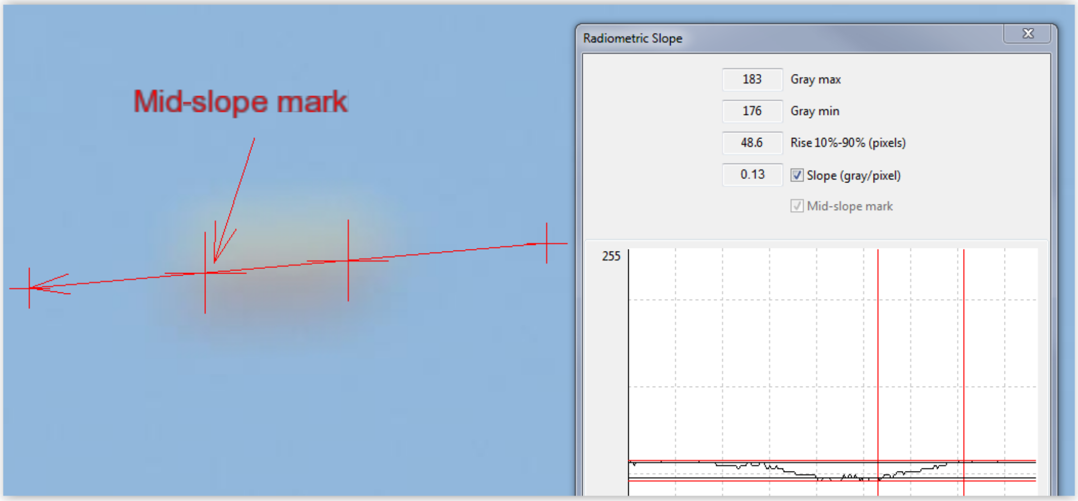
We showed that the UFO was outside the DOF.

A preliminary work is to measure the angular transverse size of the object, taking into account the length of the horizontal blur.

This can be done using the "*Mid-slope mark*" tool, in the "*Mensuration – Radiometric Mensuration – Radiometric Slope*" menu, in both directions:

***** Transverse size definition: size of the projection of the object on a plane which is orthogonal to the camera's line of sight, at the average distance between the object and the camera.





Next step is to directly measure the horizontal angular transverse size of the object between the two mid-slope marks:

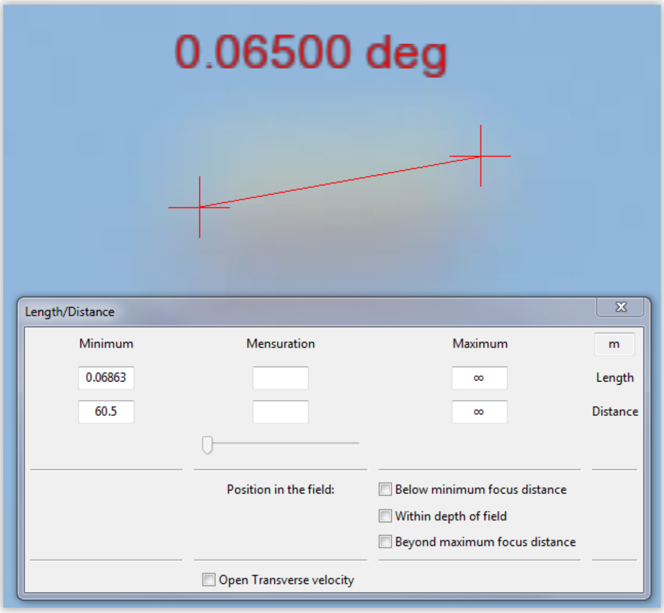
Several measurements were made and the results are comprised between 0.055° and 0.075°. For future computation, we will retain the mean value, i-e **0.065°** which is approximately the "real" horizontal angular size of the UFO, without the horizontal motion blur.

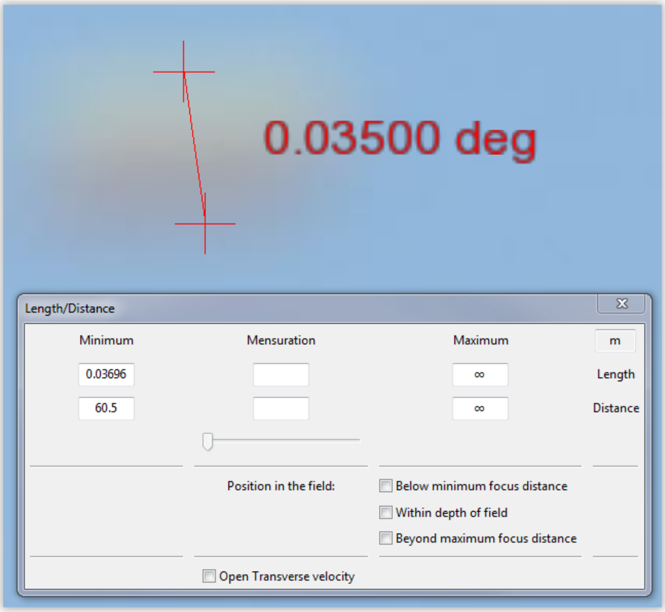
The same process can be done for the vertical axis. The vertical angular size is **0.035°.**

As the UFO is outside the DOF, it is located either below 60.5m or beyond 120.2m. It has therefore a transverse size in a range smaller than **3.7cm x 6.9cm** (for a distance below 60.5m) or larger than **7.3cm x 13.6cm** (for a distance beyond 120.2m).

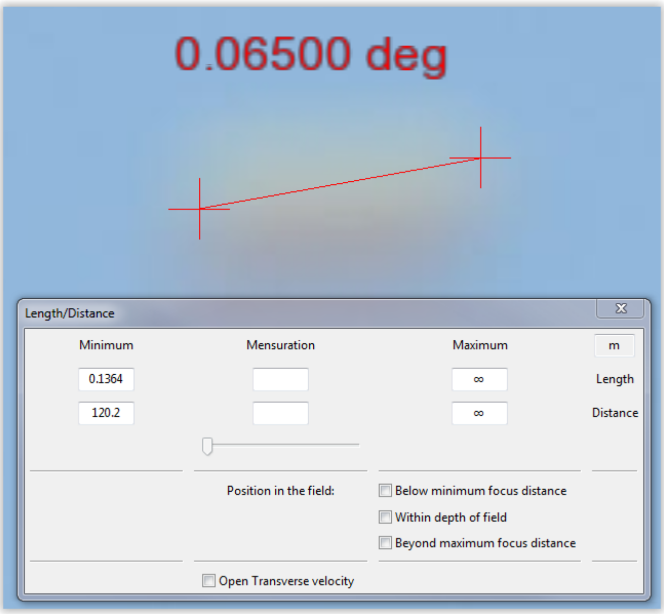
These limiting values can be computed by IPACO through the "*Length/Distance*" dialog box.

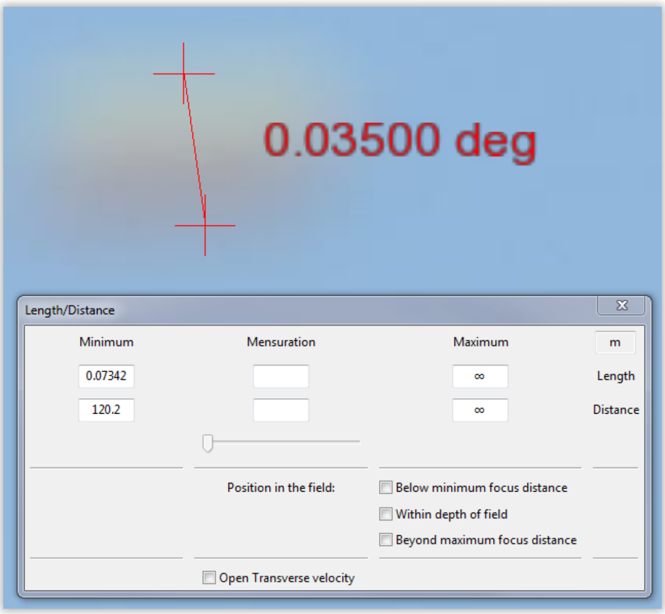
<u>For a distance of 60.5m:</u>





<u>For a distance of 120.2m:</u>





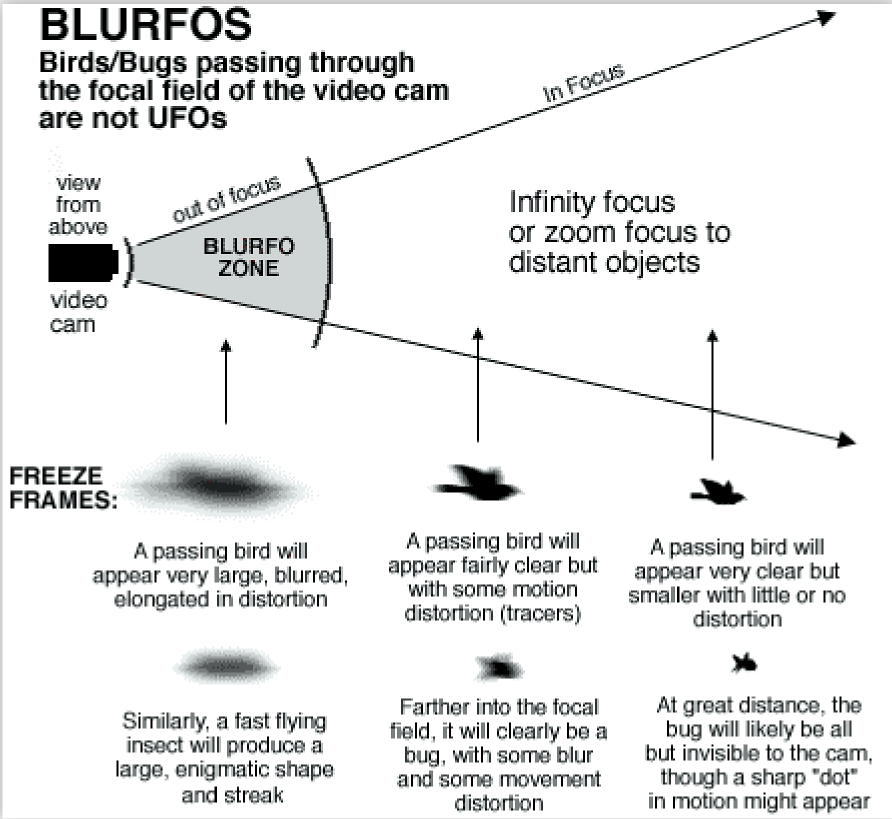
The following table gives UFO’s transverse dimensions (cm) vs distance (m) from the camera:

Distance UFO-camera (m)	UFO's width (cm)	UFO's height (cm)
60.5	6.9	3.7
120.2	13.6	7.3
200	22.7	12.2
300	34.0	18.3
400	45.4	24.4

4. Hypotheses

Blurfo

Most of the time, similar cases are easy to explain as “*blurfos*”, which is the contraction of the two words “blur” and “UFO”.



However, in the present case, it is not that simple, since the focus was not made to infinity, as explained in the previous chapter. So while the UFO still can be a “*blurfo*”, we must consider as well the possibility that it is a bigger object located beyond the farthest focus distance.

As indicated in the “*blurfo*” explanations above, for the blurry UFOs located in the “*blurfo zone*”, they comprise most of the time of birds or bugs that passed through the field of view of the camera.

Helium balloon

There is another interesting theory that deserves to be taken into account, developed and explained by Colonel Rubén Lianza as follows:

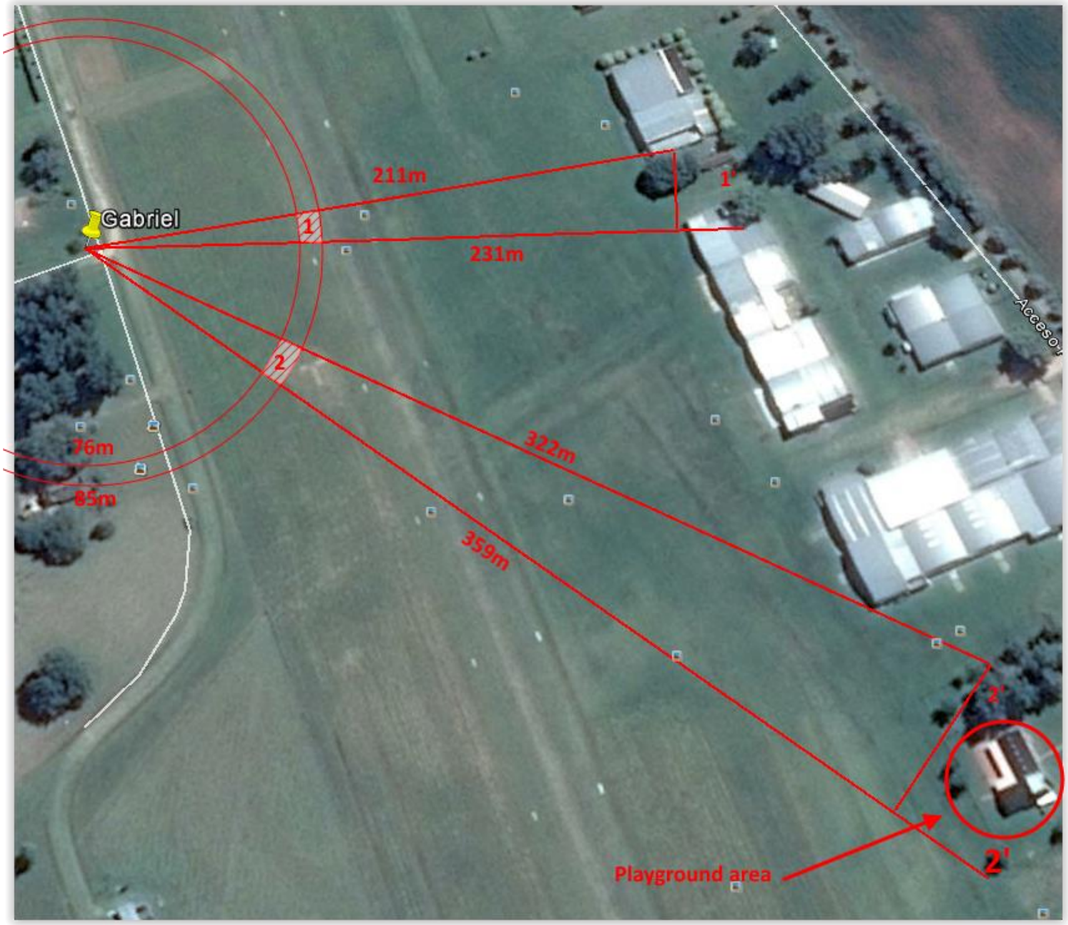
"*For what I observed during my visit to the airfield, the far trees are exactly in the restaurant area, and a restaurant area is usually where most of the people in an airshow could gather round.*

During my visit to the airfield, I also noticed that the backyard of the restaurant has a children playground with some amenities. Why am I pointing out the fact that the farther trees are in a recreational, restaurant, playground area? Because a new hypothesis could come to life if we consider this location. That of a children playing with a helium balloon (the size of a Birthday party one, let´s say 23 cm diameter)."

For this hypothesis, what is to be checked at first is the airplane position vis-à-vis the playground area position. The photographer ("Gabriel") position is known as well as its possible distances to the airplane, already determined above at the chapter "*aircraft distance from the camera*".

Further, there are some trees of which the highest part can be seen on the next photo ("D81_6490"). There are two groups of trees located at the opposite side of the runway that are visible from Gabriel's position. There are noted hereafter "1'" for the airplane position "1" and "2'" for the airplane position "2".

The corresponding lines of sight of their angular visibility and the corresponding respective distances from the camera are marked as well.



Map 1 (areas where trees are visible from the camera)

To determine which one is the right area, one can note that the trees visible on the photo still have their distinctive crown cover foliage.

There's on Google Maps an interesting sphere photo that shows all the area around the runway. It was taken in September 2016, close to the playground area:

As it can be seen, the trees in 2’ are bare of leaves, so it is unlikely to be these trees that are in the two photos following the photo with the UFO, in contrast to the trees in 1’, which retain a distinctive green foliage pattern. So the right position of the airplane is “1”.

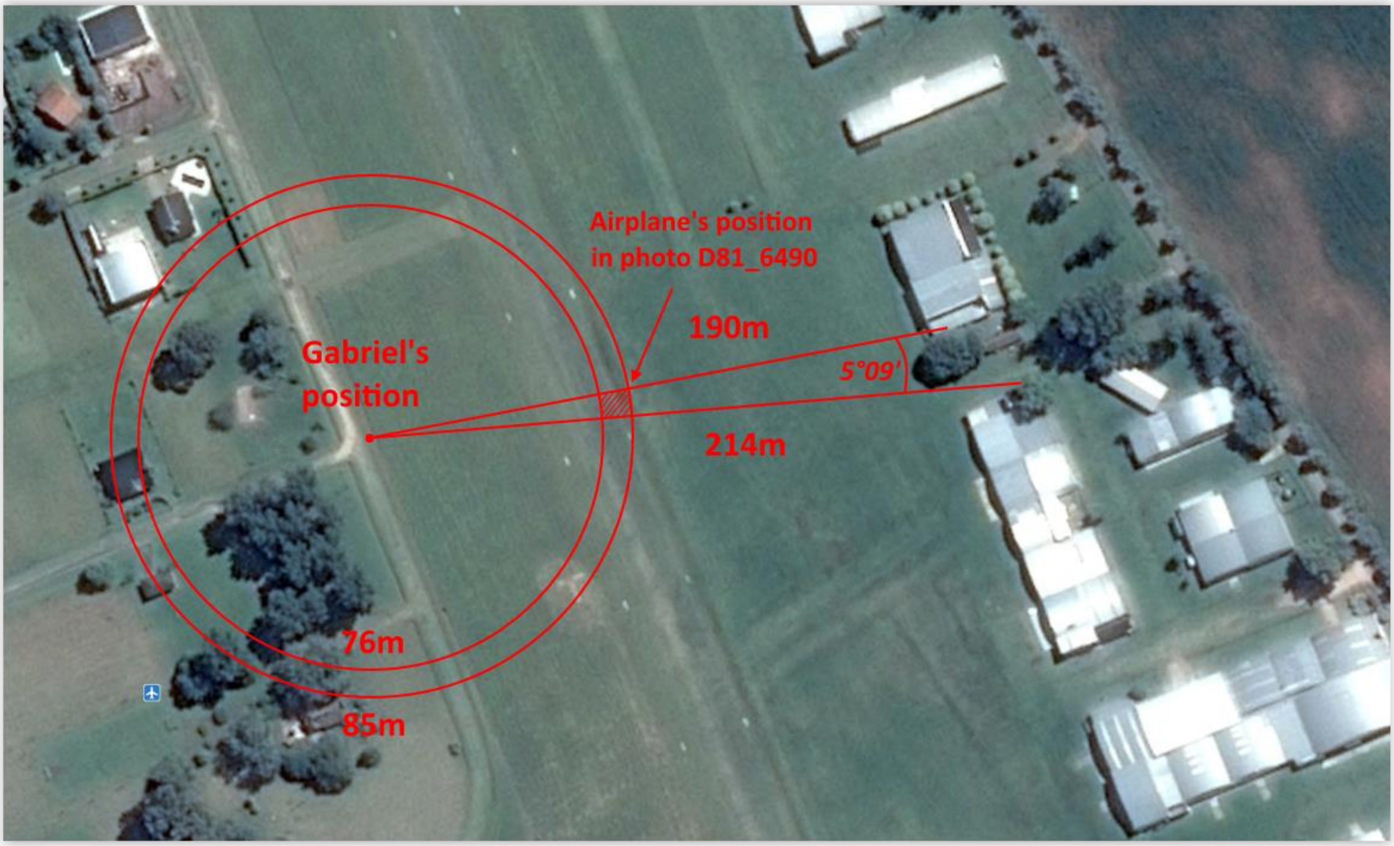
Then the new corrected “*map 2*” can be drawn as follows, it includes:

- A more precise position of the photographer.

- The consequently slightly modified position of the airplane in photo D81_6490.

- The exact angular field of view of the photo, as measured by IPACO’s tool “*Angle*” (5°09’).

- The distances between the camera and each tree as seen at the edge of the frame.



Map 2 (photo D81_6490’s field of view)

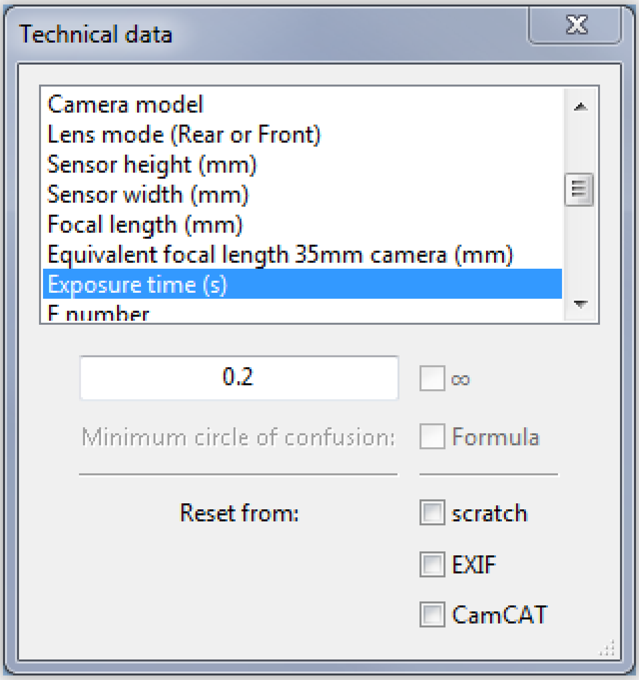
Next step is to determine the position of the airplane in the UFO’s photo (D81_6489).

What needs to be determined at first is the speed range of this airplane. It was not provided but it can be found on the Internet. The “*Zlin Z50L*” is an aerobatics airplane the speed of which ranges from 98km/h (stall speed) to 240km/h (cruise speed).

What can be done is to reconstruct its trajectory between photo n° *D81_ 6488 and n° D81_6490* taking into account these two possible minimum and maximum speeds.

There is a 0.2 seconds delay between two consecutive shots. During this period, the airplane travels at a speed comprised between 98km/h and 240km/h.

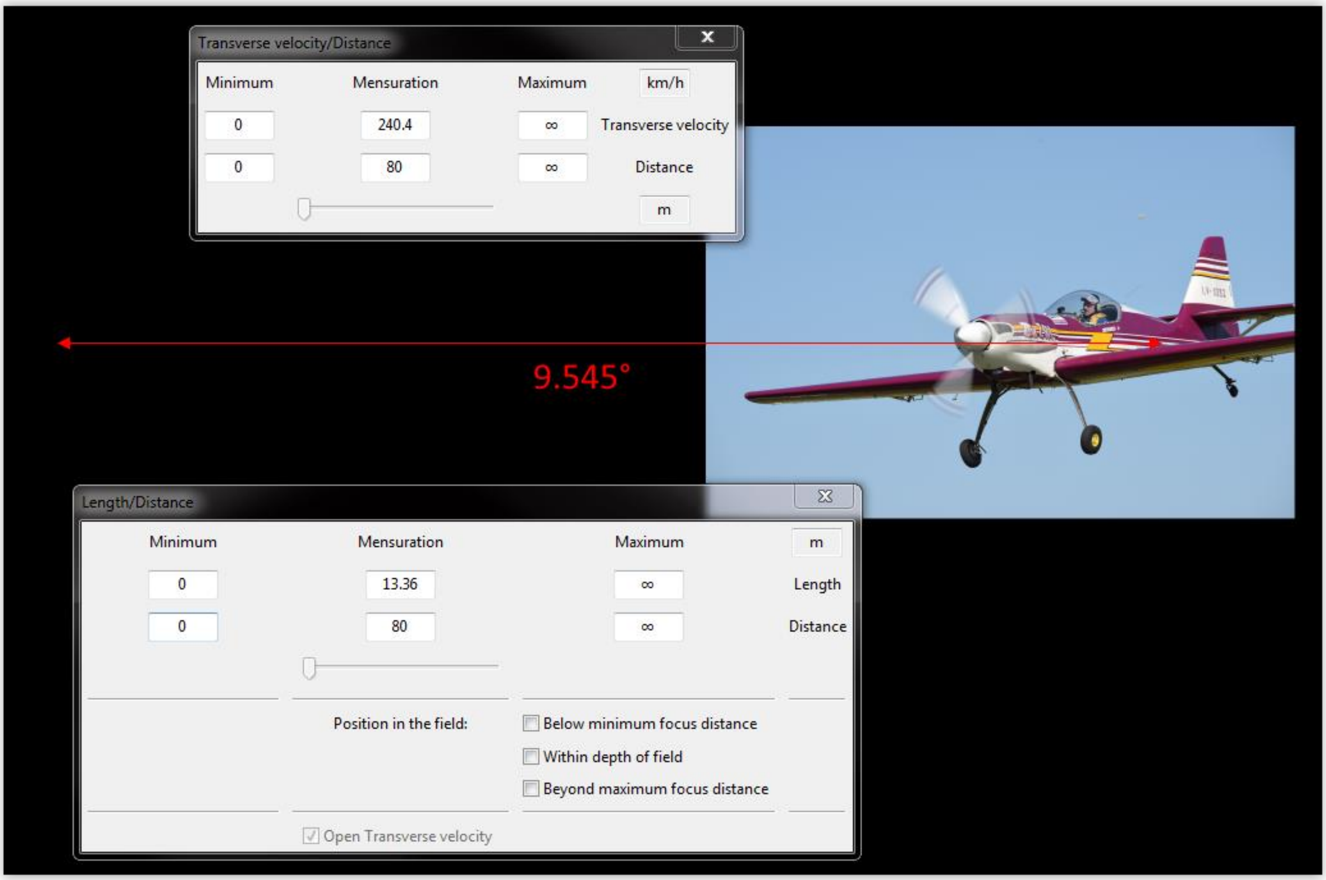
In order to represent the correct angular distance travelled during this period, it is necessary at first to manually input in "*Technical data*" a "*pseudo exposure time*" equal to the lapse of time that separates two photos in burst mode (0.2 seconds):



We can then do the corresponding size, distance and speed measurements.

Then, for a 98km/h speed, the airplane crosses horizontally 3.9° of the picture, which represents 5.44m at a 80m distance (a little less in reality, as the airplane is not moving exactly in a transverse way to the camera, but the impact on the travelled distance in negligible).

For a 240km/h speed, the airplane crosses horizontally 9.5° of the picture, which represents 13.4m at a 80m distance.



We can now report these values in the aerial map:

Map 3 (Airplane's possible positions)

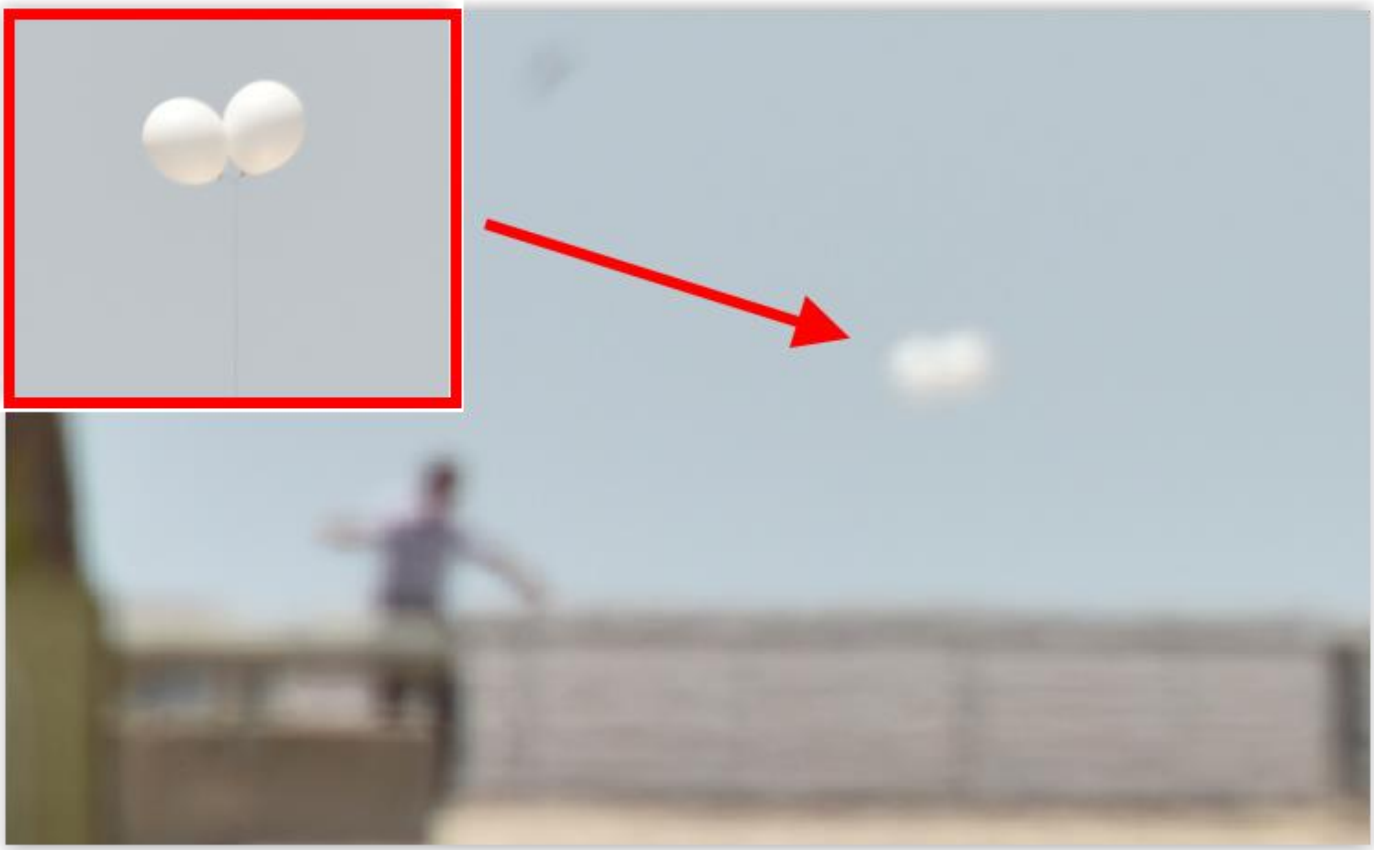
If the UFO was indeed a helium balloon, it was not located around the playground area, but rather close to area 1' in "*map 3*" above. As it can be seen on the Google sphere photo, everyone seems to be free to walk around the runway so it's possible that such a helium balloon was released around position 1'.

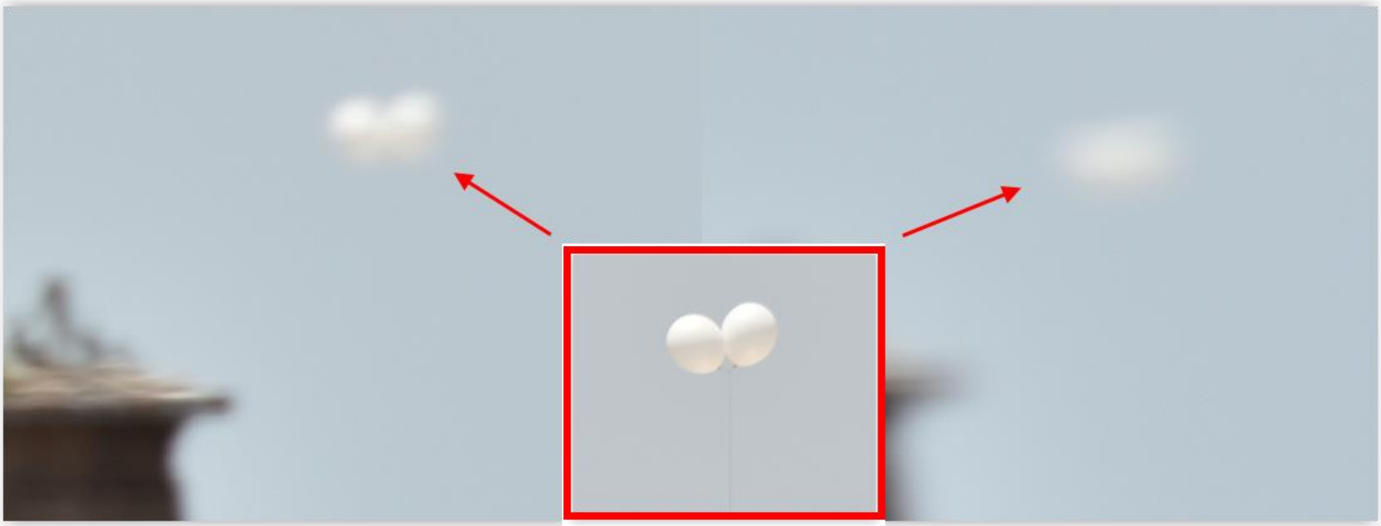
Another possibility is that the balloon was released from any position elsewhere around the runway and carried by the local wind around area 1'.

Now that we know approximately the azimuthal position where the possible balloon was standing at, we can check with IPACO its possible transverse size versus given distances.

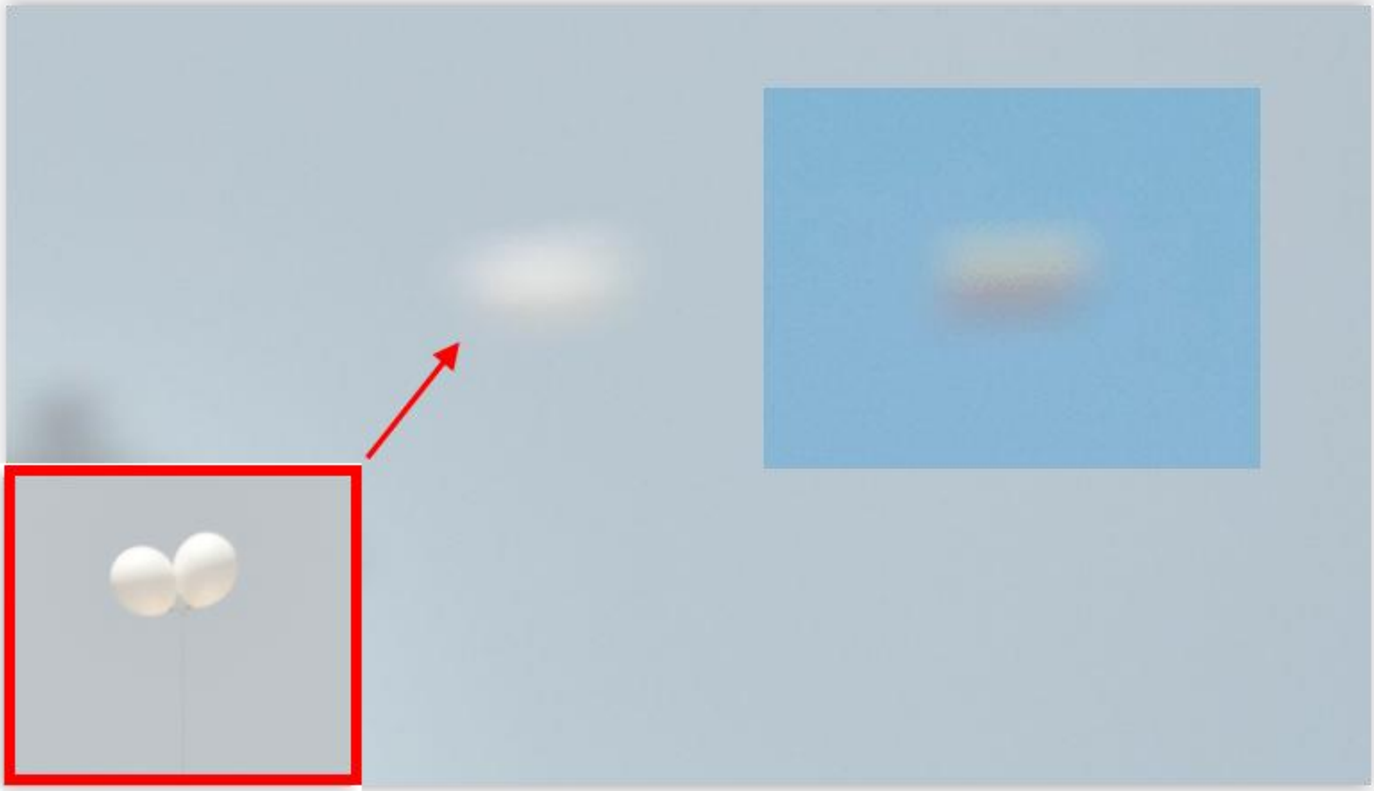
The angular transverse size of the UFO was already computed at the chapter "*UFO's distance and transverse size estimates*": **0.065° x 0.035°**.

Considering standard small helium balloons, that are about spherical with a diameter in the order of 23 to 25cm, and taking in consideration the fact that the UFO looks almost twice wider than high, a natural explanation could be that the UFO is in fact a pair of balloons linked together by a thread (which escaped the owner's hand). This explanation may be supported also by the visual impression that the UFO has a sort of "peanut shape" (as noticed by Colonel Rubén Lianza) as well by the on-site reconstitution done by Messrs Lianza and Luque with a pair of white balloons photographed at a 300m distance, with more or less blur:





Various blurs applied to the photo



Side-by-side comparison with the UFO image

The corresponding results are the following:

- If the UFO's height was 23 cm, its width was 43cm and its distance from the camera was 377m.

- If the UFO's height was 25 cm, its width was 46cm and its distance from the camera was 409m.

As an alternative solution, still in the category "helium balloons", we may consider the possibility of a balloon having a special shape that would explain the height/width ratio and its "peanut aspect".

During his on-site investigations, Colonel Rubén Lianza learnt that one of the professional photographers who were present saw such a balloon with a dolphin shape:

Depending on the observation angle, this kind of balloon could also be compliant with the observed angular dimensions of the UFO, with a corresponding distance from the camera that could be in the range from 200m up to 400m.

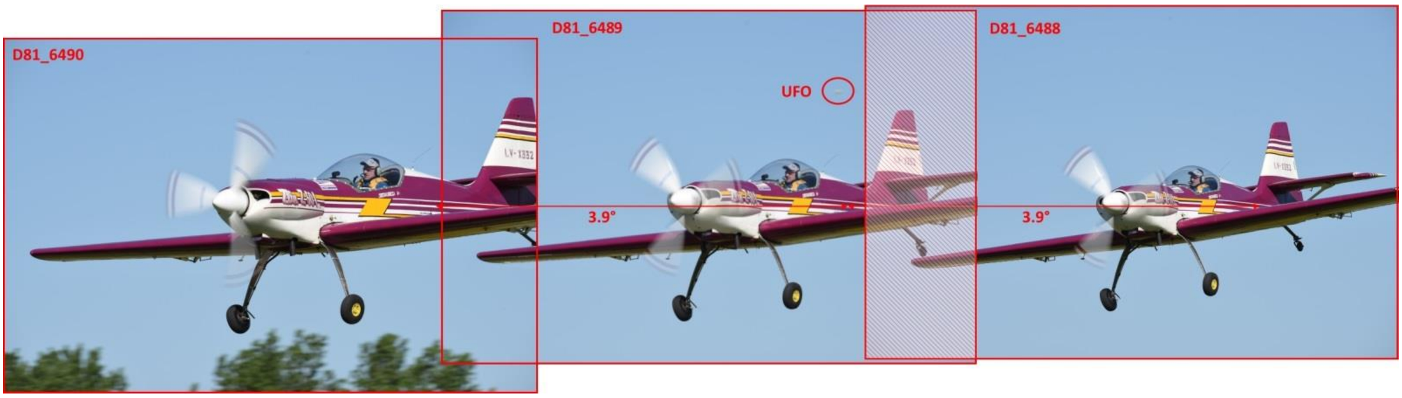
Whether a pair of standard spherical balloons or a special shape balloon, we found a simple and natural explanation for the photo, bearing in mind that it has been confirmed by several persons that on that day many helium balloons were present in the airfield, many of which were lost by their owners.

Should the UFO be visible in the previous or the following photo?

It definitely cannot be visible if the airplane was flying at its maximum possible velocity as the angle that separates each photo is too big.

However, a close observation of the sequence of 5 photos shows clearly that it was flying with enough pull-out to climb upwards after passing very low in front of the public. Its velocity was therefore certainly comprised in the standard range already mentioned (i.e. it was not slowing down as if it were going to land).

For the lowest velocity of the range, a combined image with the three photos (n° *D81_6488, D81_6489 and n° D81_6490)* shows the relative positions of the airplane in the sequence:



As the UFO position on the photo n° ”*D81_6489*” is close to the right border with the photographer moving horizontally to the left its camera, it cannot be visible later in the photo n° ”*D81_6490*”.

For the photo n° “*D81_6488*”, the UFO cannot be visible either, as, considering that it was static or moving slowly, it should be present in this case in the common section of both photos (visible in the cross-section above).

Thread detection:

In the “dolphin” balloon sample, a white thread can clearly be seen below, contrasting with the blue background sky. This should be the case for any lost helium balloon.

Concerning the possibility of a thread detection by IPACO in the UFO photo, this is definitely not possible.

As a matter of fact a couple of tests were performed with no result whatsoever. This does not mean that there was no thread, but it means that there is no available information at all about such a possible thread in the picture's pixels.

The special tool only provides useful results under certain conditions. The first and main condition is that there should exist, within the image under study, some hidden information about the existing thread.

Another condition is that the background of the picture should be "*noisy*" (more precisely it should be looking like "*white noise*"). This happens in particular when the sky (behind the suspected thread) is gray. In such cases, if there exists some remaining information about a thread, which cannot be detected through traditional edge enhancement filters because of this "noise", IPACO's special tool may be successful, since it works along a "signal-to-noise ratio enhancement" process.

In the UFO photo, not only the sky is blue (with no or very little noise), but obviously the UFO shows a strong horizontal motion blur (due to the camera's movement). This means that even if there was a thread, its contribution to the image's pixels would have been "dissolving" along the movement. It proves nothing about the presence or not of a thread, but does show that the photo does not contain any trace of such a possible thread.

IV. Conclusion

This case is classified "B", i.e. "probably explained" since, along with the *Ockham's razor* principle, there exists a simple and natural possible explanation for it.

With IPACO's tools, we explored in details all the exploitable parameters of the photograph and demonstrated that the UFO was located beyond the DOF.

We also showed that all measurable parameters and all computed results do comply with a small helium balloon (or pair of balloons), that possibly escaped from anywhere in the airfield, where many such balloons were present.

V. Acknowledgments

Special thanks to:

- Gabriel Luque, the photographer
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