IPACO expert report

Expert name	*Report date*	*Last update*
Antoine COUSYN	March 21, 2014	07/02/2020

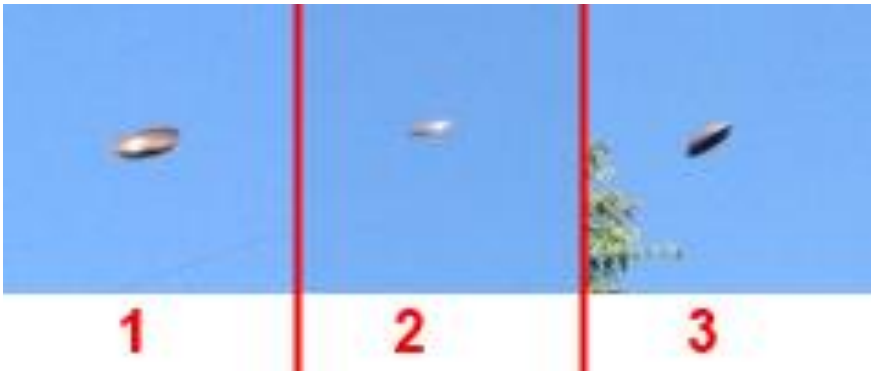
Type	*Class*	*Explanation*	*Complement*
IFO	**B**	*Frisbee-style object thrown in the air*	*Discrepancies between testimony and imaging sequence*

Document	*Imaging location*	*Imaging date*
Photographic	Nashville, Tennessee USA	April 11, 2013 between 01:41’:15’’ and 01:41’:36’’PM

Photograph « object1.jpg » taken at 01:41’:36’’ PM

Photograph « object2.jpg » taken at 01:41’:16’’ PM

Photograph « object3.jpg » taken at 01:41’:15’’ PM



Close-up views of the object

I. Imaging circumstances

The following synopsis is extracted from the US forum "Above Top Secret".

"I don't know where to start.... at approximately 4pm today I was outside behind my house in Nashville, TN smoking a cigarette and playing fetch with my 6 month old dach-griffon puppy. Suddenly my dog starts acting strange, runs to get the stick we were playing with and suddenly he stops moving; the usual playful energy in his face and general demeanor just drop and he sits there a few feet in front of me.

I look up into the sky and see a metallic gold disk shape off in the distance what looks to be a few hundred feet behind the trees/rooftops. I stood there for a few seconds, grabbed my phone out of my pocket and snapped the following shots. It's just sitting there in the sky, then in an almost comically cliché's fashion it sort of rolled/turned on its side and zips upwards and to the left and out of sight at a pretty rapid pace.

The phone I took these with was an Iphone 4s. Anybody that has one of these knows that when you open the camera app, it is set on picture/video record as a default depending on how you last had it set. Mine happened to be on still photo mode, I wish I had a chance to get video but it literally disappeared as soon as I started snapping (read below for more details).

I literally grabbed the phone from my pocket, opened up camera and started mashing the shutter button as fast as I could, resulting in about 4 frames per second at a fairly regular rate. These are the only 3 in which the object appeared, from what I've looked through so far; I will check again though in case I missed anything. The strange part is it seemed to make an exit as soon as I pointed my Iphone at it. I have no doubt whatsoever that it was hovering at least the entire time between me spotting it and taking the phone out my pocket/opening camera app and pointing.

So here's the pictures, original unedited in the 'large' JPEG option (that you select when emailing Iphone photos to a computer for upload, I do have the original raw files on my phone, but the 'large JPG' option always has in my experience been just as good quality as the 'actual size' raw... I know it will come up eventually so know I'm prepared to upload these too.... I'm just hella excited about this and had to post ASAP!!"

II. Camera settings

The camera model used was an IPhone 4S of which technical characteristics are shown in details *here*.

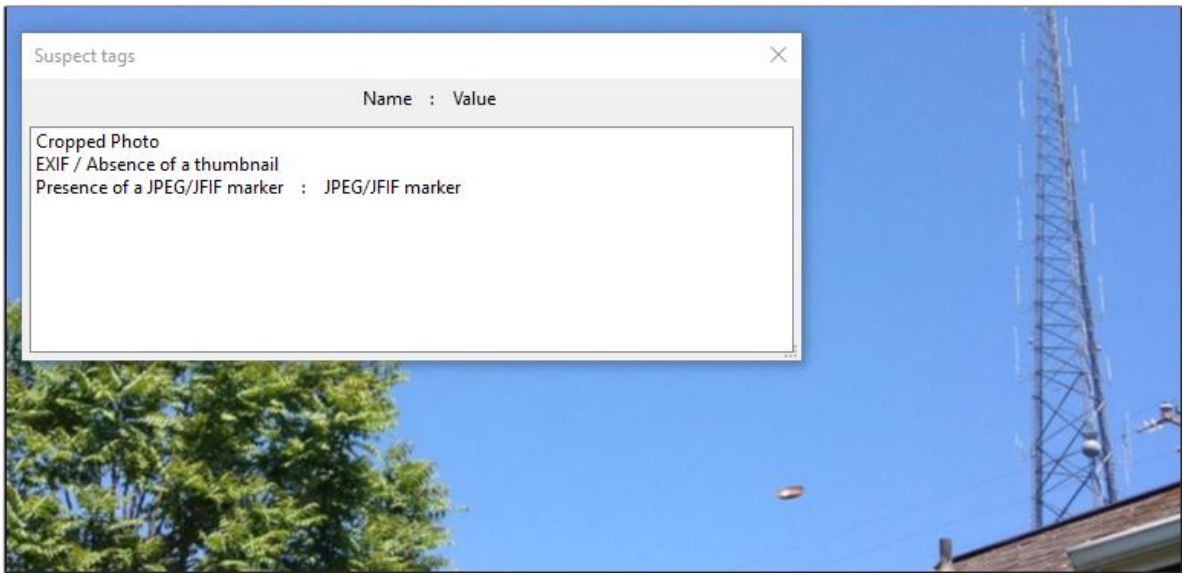
III. Data examination

1- Authentication

A document is deemed authentic original, within the meaning of the "*IPACO Analysis Methodology*", if it results from a direct copy of the original file created in the camera.

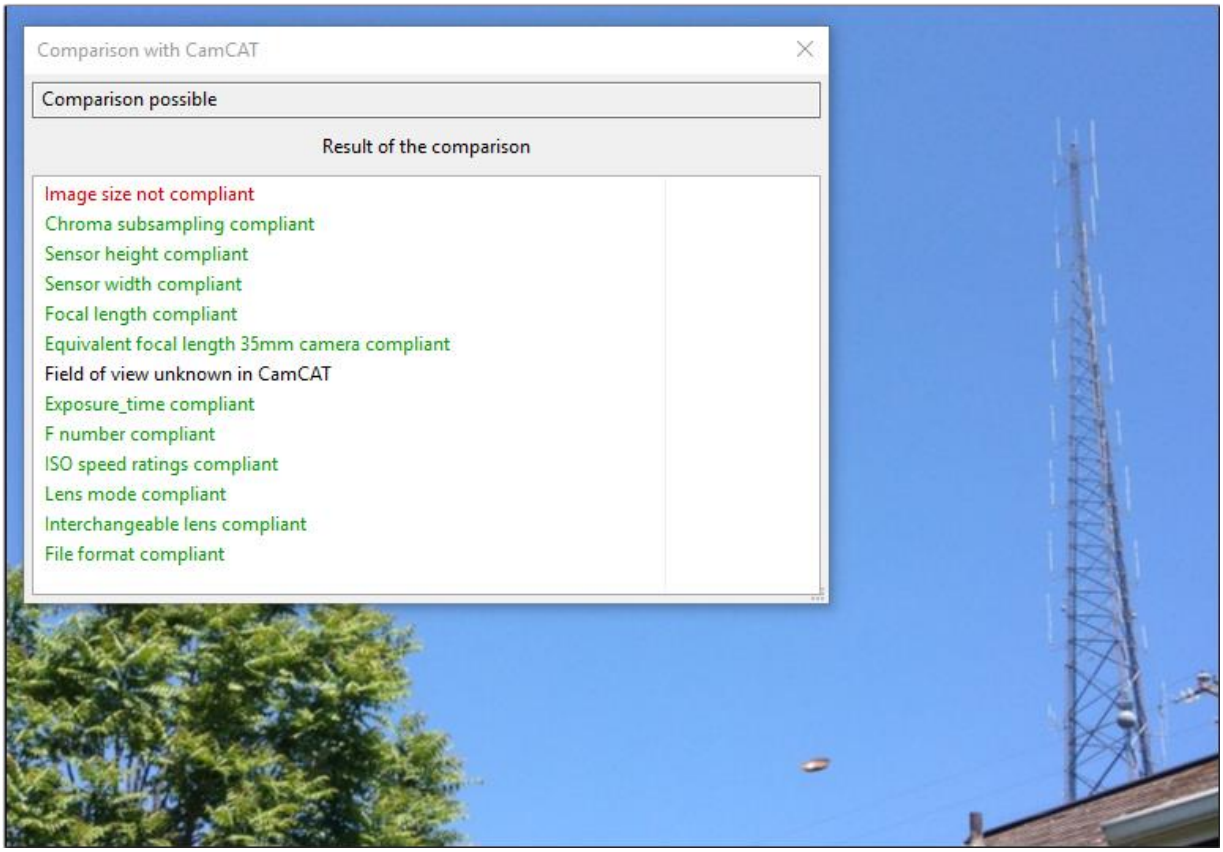
Any modification, made either to the file whilst still in the memory of the camera, or later, can be detected by IPACO with the "*Authentication*" module, in two different possible ways; the results can be displayed together in the IPACO window.

The "*Suspect tags*" tool, in particular, can be used to determine, for example, the possible use of third-party software:



In addition to this mention of cropped photo, we note the absence of a thumbnail and the presence of a JPEG / JFIF marker. These last two tags, although often appearing when the photograph has been through an online storage or a sharing site (and therefore not necessarily reflecting a forgery), are nevertheless considered suspicious by default, because they can also appear in more dubious circumstances, such as the use of editing software.

The « *Comparison with CamCAT* » tool allows the analyst to compare the technical data of the studied file with an internal database, in order to check if they comply with what the camera used can produce:

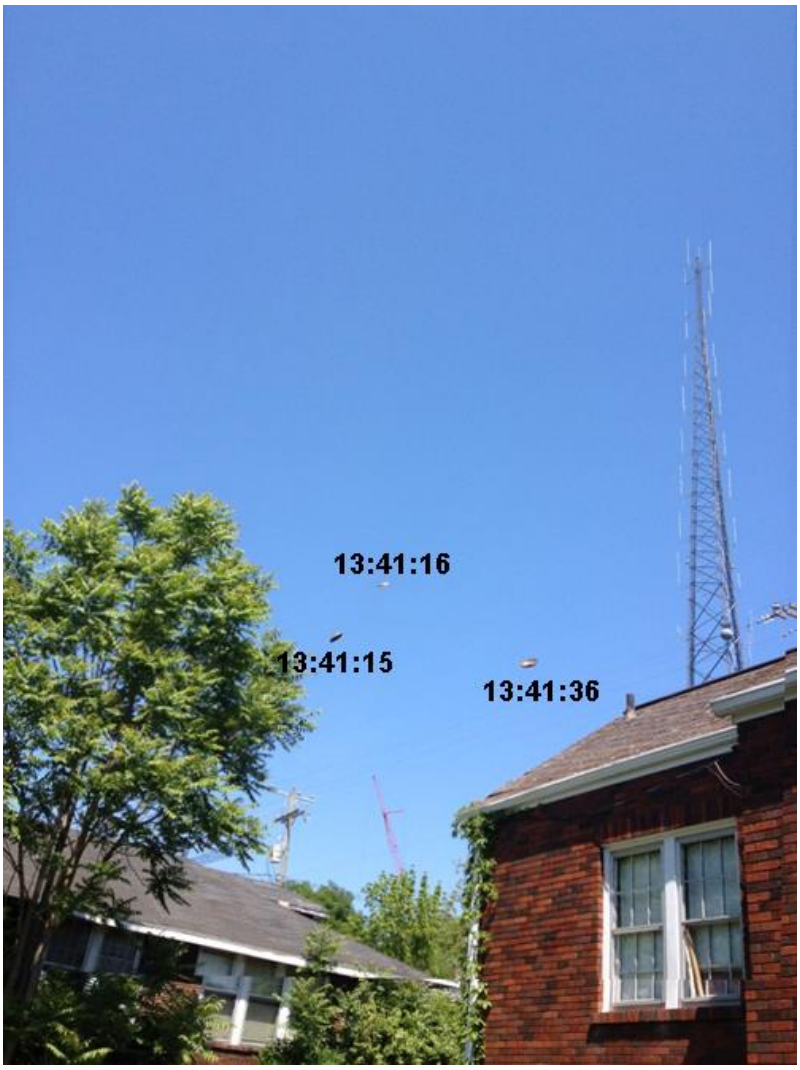


All the parameters are compliant, with the exception of the image size, for which we find here again the non-compliance (cropped image) already reported with the "*Suspect tags*" tool.

2- Reading and quick study of the metadata

The name of the files is not the one that is automatically assigned by the camera, but was modified afterward by the photographer: « *object1* », « *object2* » and « *object3* », then, chronologically, ***in the reverse order*** of the three pictures sequence, according to the metadata:

- «*Object3*» : 2012 :04 :11, 13 :41 :15
- «*Object2*» : 2012 :04 :11, 13 :41 :16
- «*Object1*» : 2012 :04 :11, 13 :41 :36



The three photographs have been taken with the same automatic exposure mode, with the following characteristics:

- ISO 64.
- Aperture f/2.4.
- Exposure time: 1/1104 s for photo « *object1* »and 1/1062 s for the others.

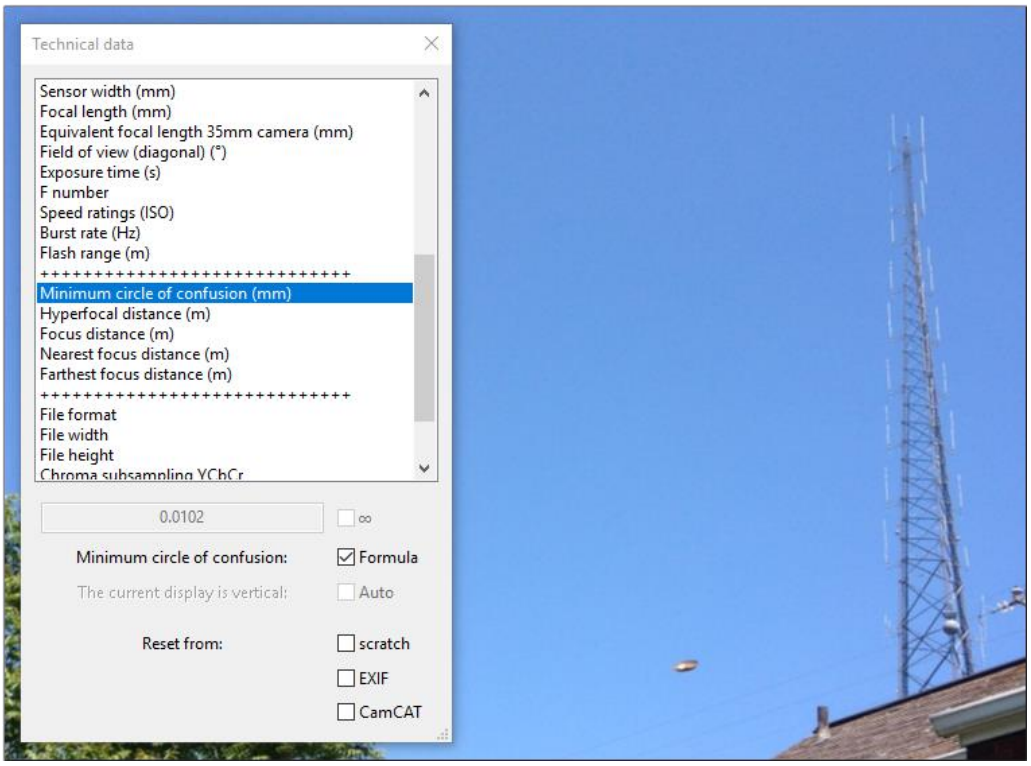
Images size is 768 x 1024 (height/length ratio 1.33), which correspond to a decrease of the initial maximal possible size for a JPEG file created with an IPhone 4s (2448 x 3264) by approximately 10.

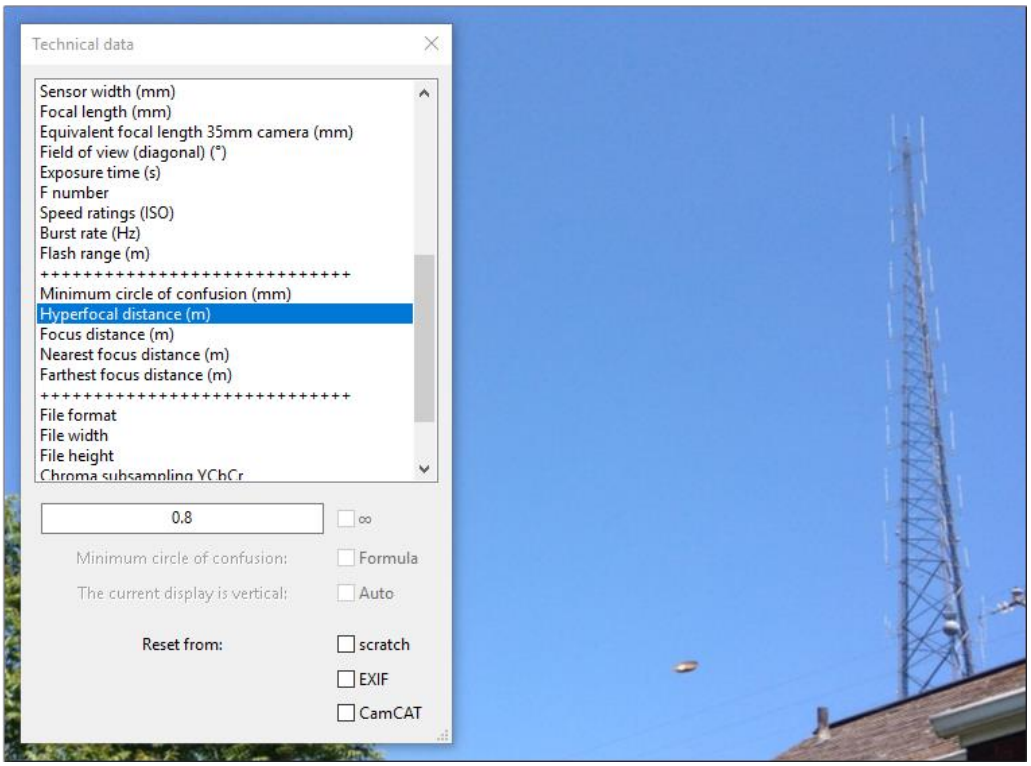
This 768 x 1024 image size is **not allocated by default** in the camera, which automatically, i.e. without any user intervention, produce maximal image size of 2448 x 3264.

Additionally, focal length value is 4.3 mm and angle of view 54.4°.

Minimum circle of confusion CC* and hyperfocal distance can be determined by IPACO in "*Technical data*" simply by ticking the "*Formula*" box. The circle of confusion has here a value of 0,0102 mm and the hyperfocal distance of 0.8 m:

* *$CC = 1.5 \times \sqrt{[(H_C / Row)^2 + (L_C / Col)^2]}$; with H_C Sensor height (mm), Row Image height (pixels), L_C Sensor width (mm) and Col Image width (pixels) (Empirical formula proposed by default)*





The focused object is then located at an equal or further distance from the photographer than 0.8 m.

3- Two different but complementary methods

In order to study this file in the most complete possible way, we will present measurements and calculations performed using two very different approaches, nonetheless complementary:

- *A radiometric approach* that, by the comparative measurements of the darkest gray pixels levels of various « *dark* » known objects of the scene, and for which we know their distance from the photographer, will allow us, in an empirical way, to give an estimative range of the size of the unknown object.

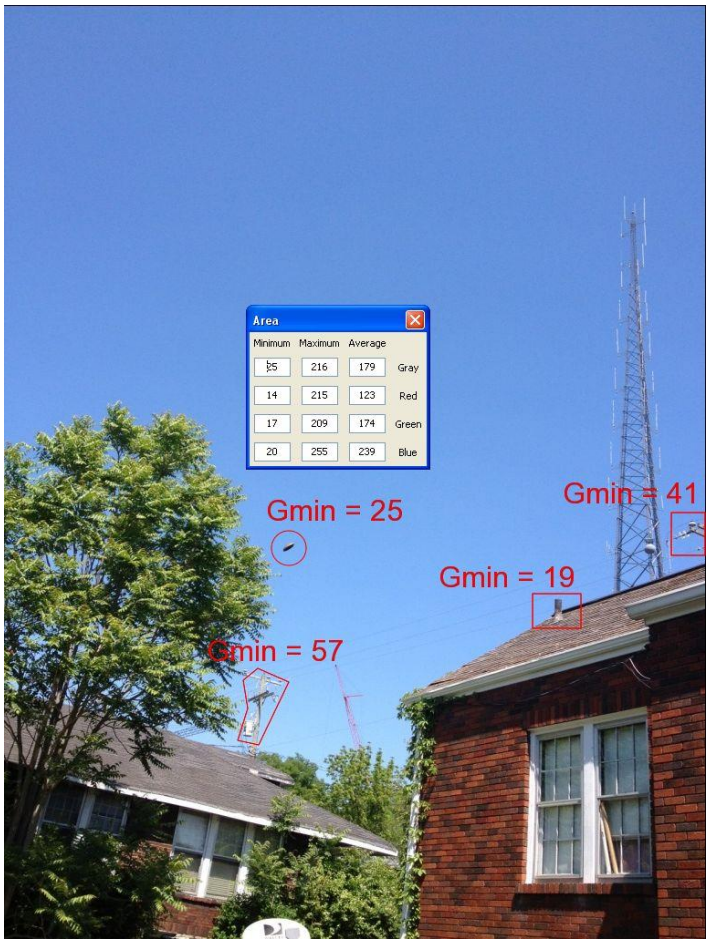
- *A geometric approach* that, with the help of various angular measurements from known objects of the scene (e.g. size, distance…), of simple trigonometric relationships and of the dedicated available IPACO tools, will allow us to perform various measurements (elevation, speed…).

These two approaches will be tested through the following chapters and their results compared in the conclusion which will assess the validity of the hypothesis.

4- Radiometric measurements

On photograph « *object3* », the object clearly shows a black part. We can try to establish a classification of the respective distances between the camera and various parts of the scene that contain dark parts, not exposed to the sun light, in a blue sky background (similar conditions versus atmospheric diffusion).

Using this concept, several areas have been drawn on the photography «*object3*» and the grey level G_{min} of the darkest pixel of each of these areas have been noted with IPACO:

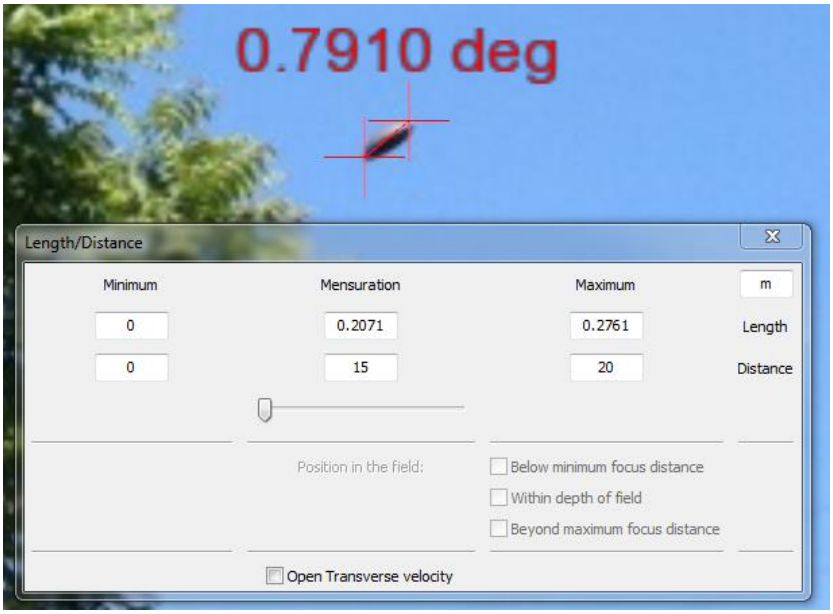


End of the summit of the right roof	:	G_{min} = 19	Distance	≈	14 m
Studied object	:	G_{min} = 25	Distance	≈	?
Power pole right	:	G_{min} = 41	Distance	≈	25 m
Power pole left	:	G_{min} = 57	Distance	≈	48 m

From this it can be deduced that the distance between the object and the smartphone is very likely to be between 14 m and 25 m. A linear interpolation (very empirical) indicates a distance around 17 m.

Given the uncertainty of the calculation method, we will note that the object was at a distance from the camera of **between 15 and 20 meters**.

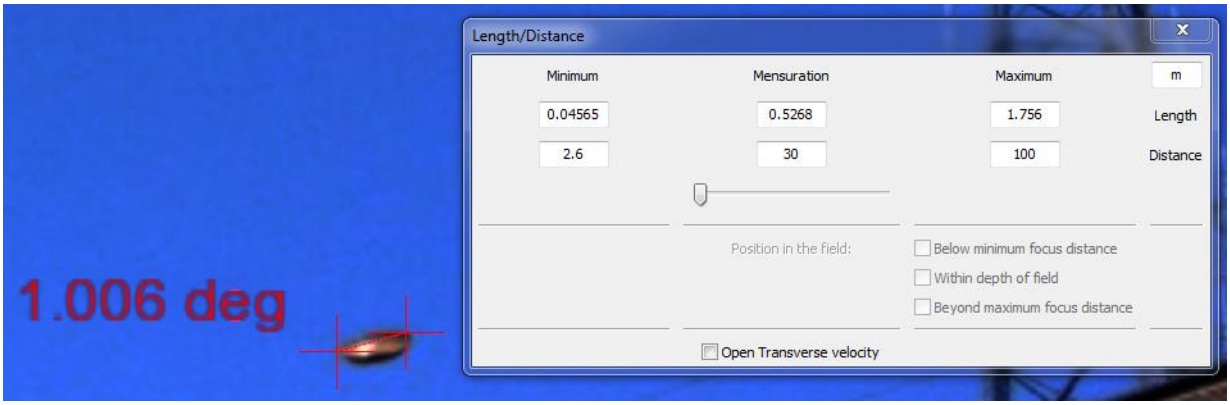
We deduce from this, thanks to the "*Length/Distance*" tool that allows us to estimate the size of the object based on its distance and vice versa, that its diameter was probably **between 21 cm and 28 cm**:



5- Geometric measurements and hypothesis

a- Position of the photographer and of the object

The technical characteristics of the camera being known (focal length…), we can firstly, still with the help of IPACO's tool "*Length/Distance*", quickly compute the angular size of the object, which is for example, on the photo "object1", approximately 1°.



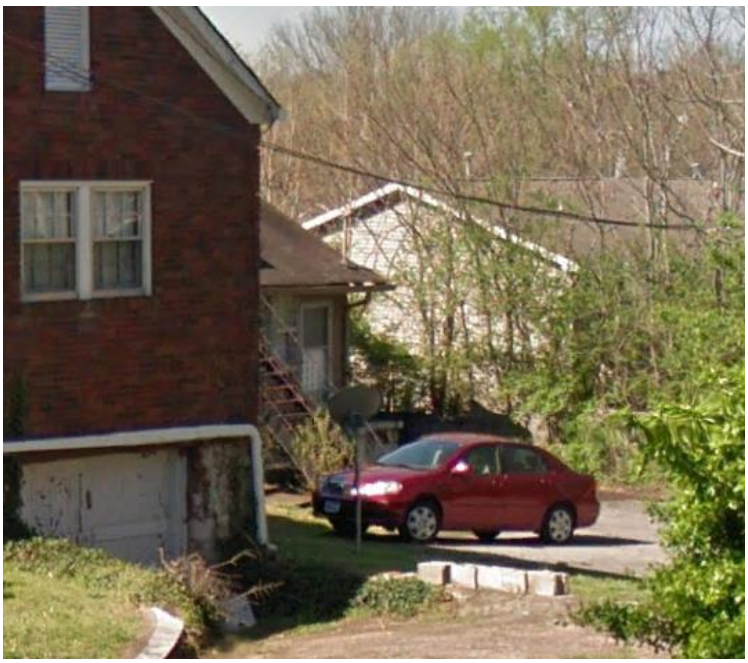
Then, and under the hypothesis of the object being rather close, if it is located for example 2.60 m away, its longest length is 3.5 cm. If located 30 meters away, its length is 53 cm and if located 100 meters away, its length is 1.77 m.

Likewise, using the hypothesis of a distant object, its length is 5.30 m if it is located 300 meters away, 17.70 m if located 1 kilometer away and 53.10 m if located 3 kilometers away.

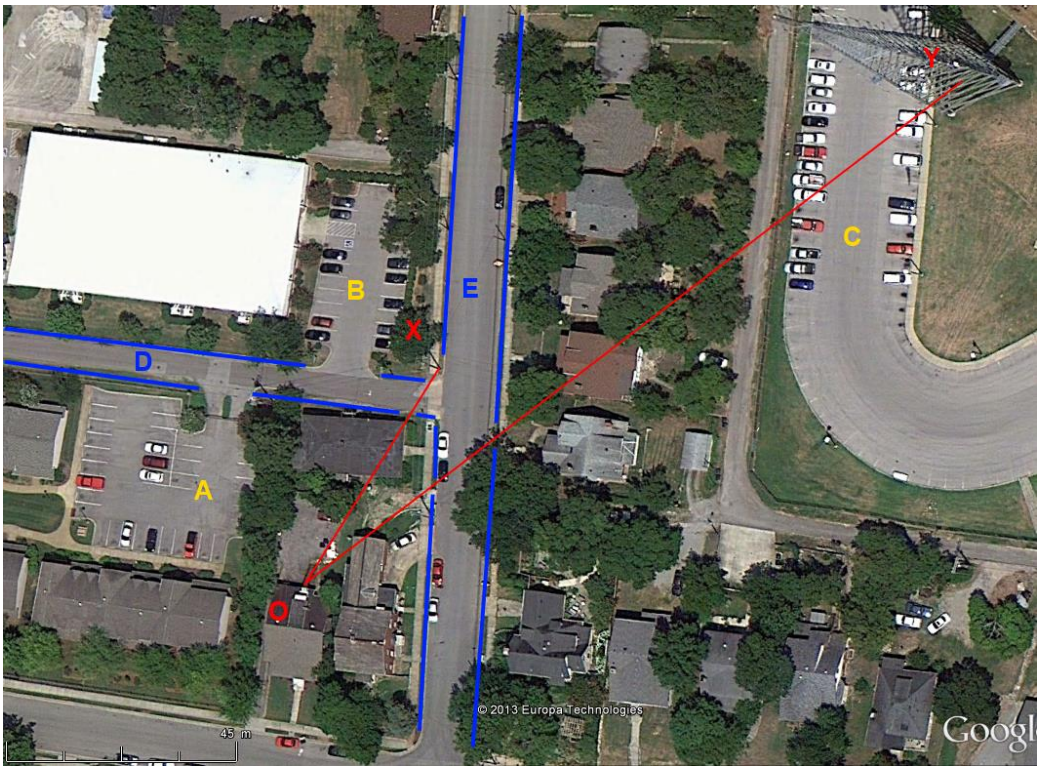
For the record, the result given by the radiometric approach expounded in the previous chapter was a diameter for the unknown object somewhere in between 21 and 28 cm for a distance from the camera of between 15 and 20 m.

GPS coordinates are present in the metadata associated with the JPEG file. We can then thus easily find the location of the sighting and better define it using angular measurements of the camera field of view and the visual landmarks visible on the photographs as well, and then proceed to making some ground measurements.

Thus we note that the photographer could only be located in a specific position on a staircase that goes from a house to a courtyard that can be seen in the screenshot below, as well as the dish mounted on a pole visible at the bottom of the photograph « *object3* »:



General overview of the area:



The power pole marked as « X »on the ground plane above is **48 m** away and the metallic pole “Y” **148 m** away from the photographer (« O »). The object is located (under the hypothesis of it being close), on each photograph, within the angle made by the straight lines that connect the photographer’s position to each of these two landmarks.

Assuming that a rather small object was thrown in the air, there are many places around there, freely accessible and with no significant traffic, from which someone else could launch this object in the line of sight of the photographer without being visible himself.

This is the case for example of parking « B », (« A » and« C » being closed to the public) adjacent to the small courtyard from which the photographs were shot, but also the small street « D »and the left parts of the courtyard that are not in the line of sight of the photographer (indicated « G » and « G1 » below).

We also retain as a possible area the immediate vicinity of the house (indicated below as « F »), between the photographer and the avenue “E”.

Possible areas from which an object could have been launched without the launcher being visible by the photographer

We can check if the assumption of a small and close object is compatible with the subsequent observations, measurements and calculations.

One second separates the photographs « *object3* » and« *object2* ». Only one launch would be enough then for these two pictures, the object moving towards the upper right corner of the image, in relation to the photographer. However, the photograph « *object1* » is separated by 20 seconds from «*object2* », which means that it was made during another launch, later.

Precise measurements on the angular size of the object give us the following results:

- Photograph « *object1* » : 1,01°
- Photograph « *object2* » : 0,74°
- Photograph « *object3* » : 0,79°

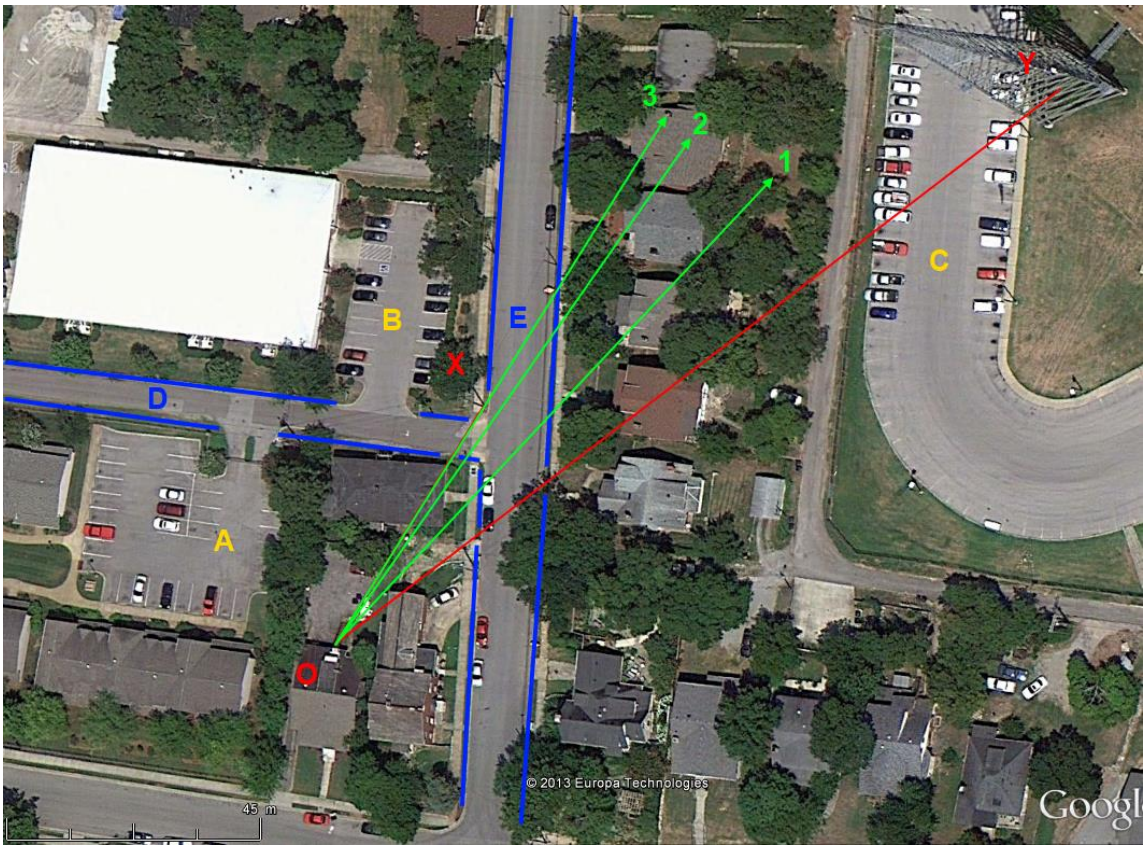
The object in the photograph « *object1* » looks larger, indicating that it is a little closer, which, combined with the lapse of time that separates the shots, confirms that this photograph was probably taken during a second occurrence.

Furthermore, the difference between the angular sizes of the object in both position « 2 » and « 3 » is very low, indicating that it is located substantially in the same plane perpendicular to the camera boresight. The existing margin of error in measurements made on photographs with mediocre resolution does not allow us to clarify this point further.

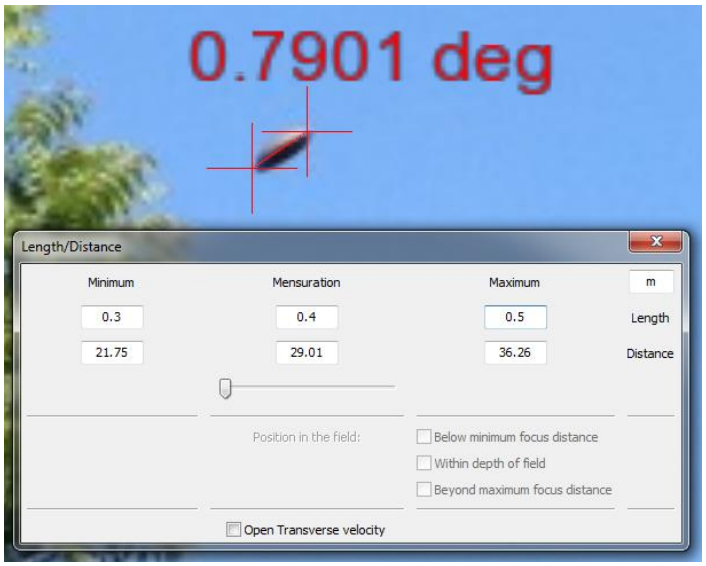
The next step is to determine the horizontal angular position of the object on each picture. The total horizontal field of view covered by the image measured by IPACO is 39.73°. We can then define the position of the power pole and use it as a reference for measuring the angular position of the object in each image:

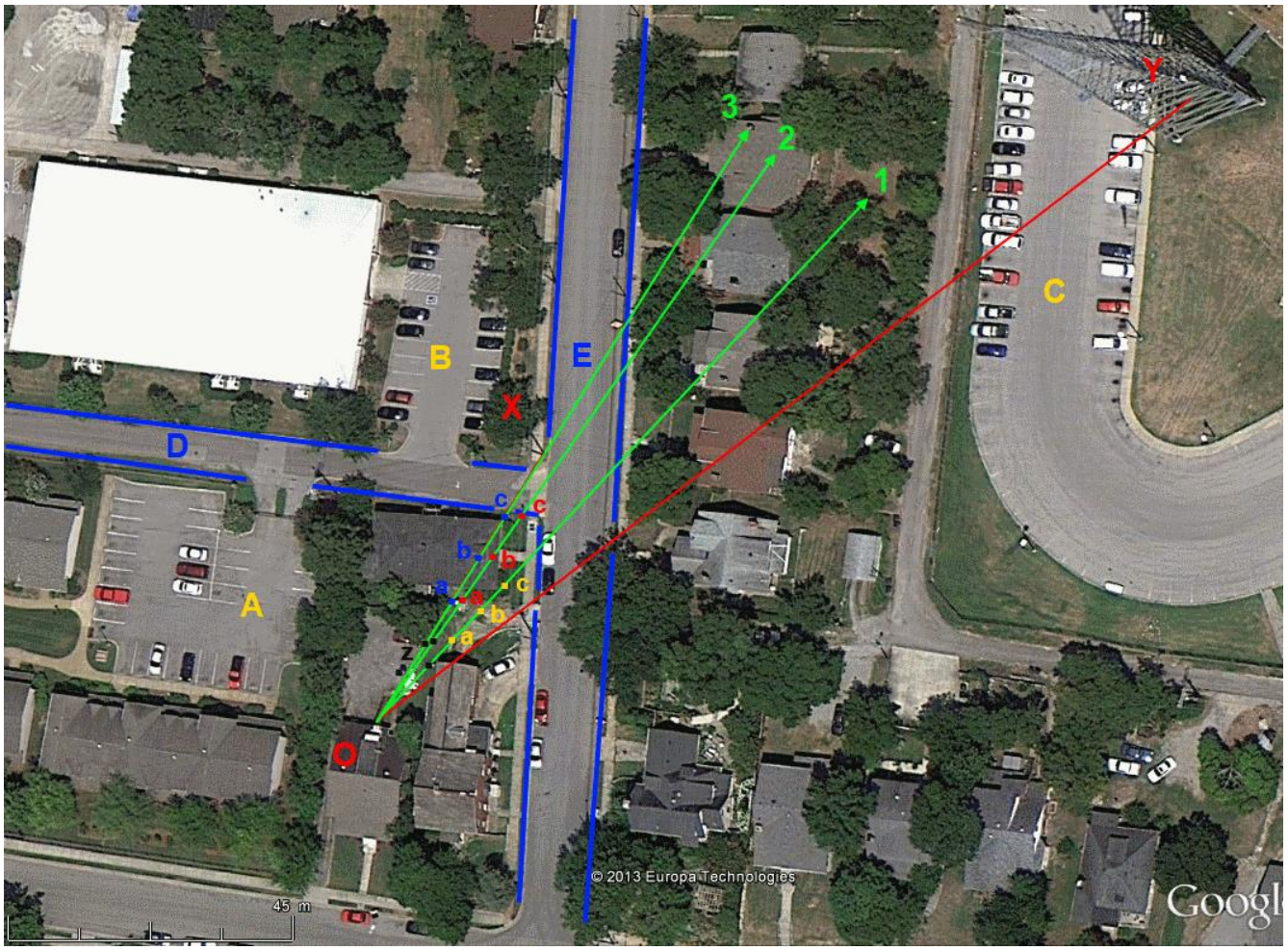
- Photograph « *object1* » : 11.6°
- Photograph « *object2* » :3.2°
- Photograph « *object3* » : 0.4°

We can copy these measurements on the ground plane:



Then, on each plotted line, we can project the respective possible positions, seen from above and in orthogonal projection on the ground, of the object according to various possible estimates of its size (20, 30, 40 and 50 cm diameter) and of its distance calculated by IPACO as outlined in the beginning of this chapter:





Then, « z » shows the position of the object if its length is 20 cm, « a » if it is 30 cm, « b » if it is 40 cm and « c » if it is 50 cm.

Noting that …

1- The movement of the object between photographs « *object3* » and « *object2* » was made in a “diagonal way”, i-e towards the upper right corner of the image.
2- The angular size of the object has hardly varied between these two images.

…so:

-The launch was made from the ground in an upward motion and on a plane parallel to that of the camera…

- However this is **impossible** from positions « a » and « b » as defined above, the « launcher » being therefore visible (from the photographer position and at least for photograph « *object1* »), or its position or the trajectory of the object being in an inaccessible or impassable area (roof, trees …) or also in an area too far away (further away in street D for example).

The difficulty of the launch of such an object from this latter position should also be taken into account, as this place is particularly blocked (power pole, electric wires, trees…):

Consequently, still maintaining the hypothesis of a small object:

- It measures either **about 20 cm** or **about 50 cm** in its greatest length.
- So **it could only be found in either**:

o **Configuration "c"and have been launched from the street "D",** near the junction with avenue "E", for both photographs "*object3*" and "*object2*" and from another location nearby for photograph "*object1*", or

o **Configuration "z" and have been launched from area "G",**in the courtyard.

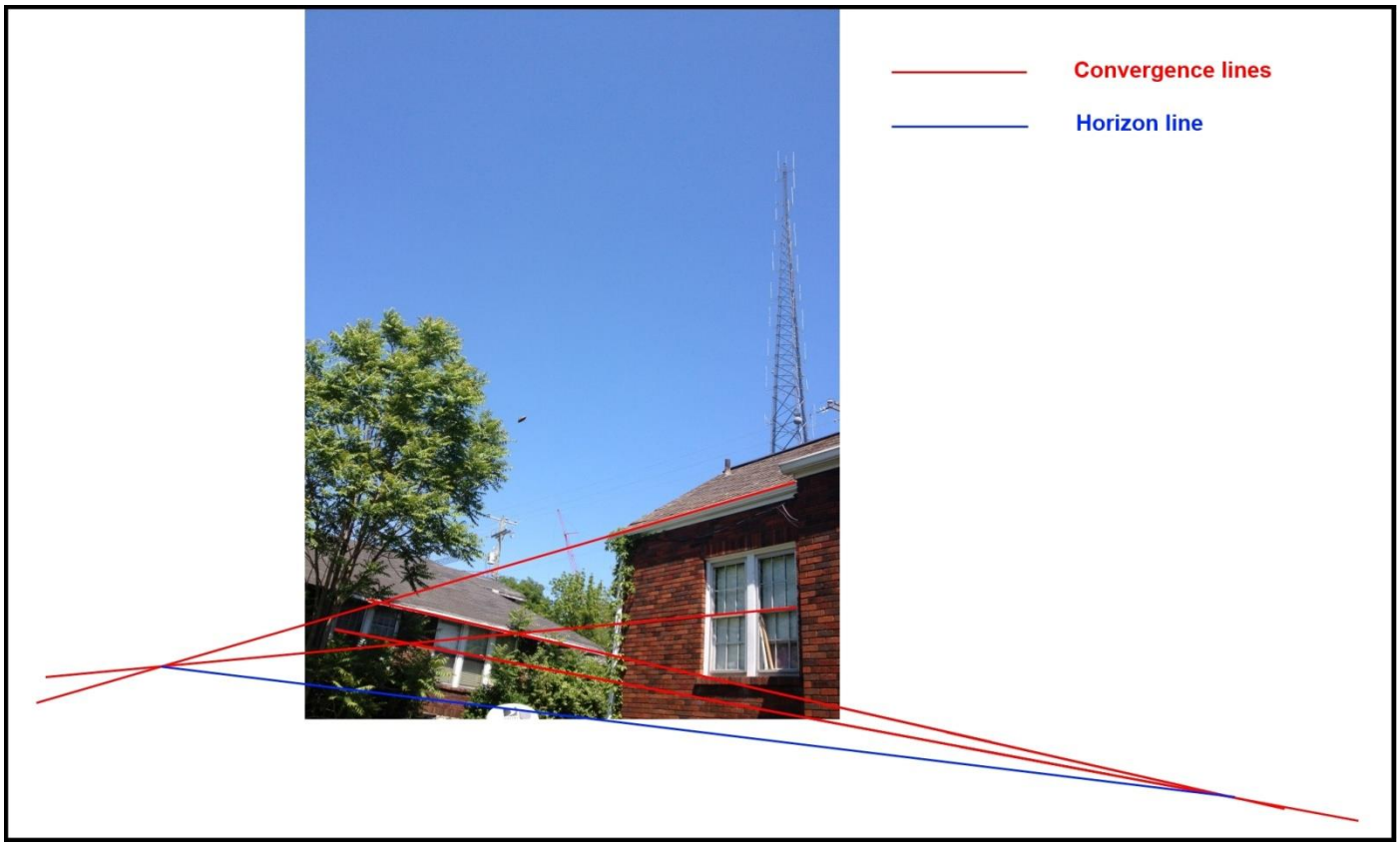
- The distance that separates the photographer and the position of the object in "c", in its orthogonal projection on the ground (as measured on a map) is **about 36 m** for the two photographs "*object3*" and "*object2"*, and **about 28 m** for photograph "*object1*".

- The distance that separates the photographer and the position of the object in "z", in its orthogonal projection on the ground (as measured on a map) is **about 14 m** for the two photographs "*object3*" and "*object2*" , and**about 11 m** for photograph"*object1*".

b- Elevation calculations

Furnished with the above results, still assuming an object with a diameter about 50 cm launched from the ground, we can try to so some elevation measurements above ground level.

We need at first to define the horizon line through horizontal landmarks located in each photograph:



Then, thanks to IPACO's tool « *angle mensuration* », we can easily determine the angular elevation AGL (marked « *Ô* ») of the object in each photograph:

- Photograph « *object1* » : 21.0°.
- Photograph « *object2* » : 25.0°.

- Photograph « *object3* » : 21.0°.

These angular elevations are very close to each other.

A simple trigonometric relationship in the right-angle triangle OBC, with O as the photographer position, B the object position in its ground orthogonal projection and C the object position, allows us to compute the BC distance which corresponds to its actual elevation; OB being the distance that separates the photographer from the position of the object in its orthogonal projection to the ground, as defined above, and OC the distance between the photographer and the object.

We write: ***BC = Tan Ô x OB***, then an elevation for the object equal to:

- For configuration « z » :

- Photograph « *object1* » : **5.4 m.**
- Photograph « *object2* » : **6.8 m.**
- Photograph « *object3* » : **4.4 m.**

- For configuration « c » :

- Photograph « *object1* » : **13.8 m.**
- Photograph « *object2* » : **16.8 m.**
- Photograph « *object3* » : **10.7 m.**

c- Distance between photographer and the object

It can be determined easily thanks to the results obtained in the previous chapters and to the application of the Pythagorean Theorem. The square of this distance is equal to the sum of the square of the altitude and the square of the distance between the photographer and the position of the object in its orthogonal projection to the ground, i-e $\mathbf{OC^2 = BC^2 + OB^2}$.

- For configuration « z » :

- Photograph « *object1* »: $\mathbf{OC^2 = (5.4)^2 + (11)^2}$**; OC = 12.3 m.**
- Photograph « *object2* »: $\mathbf{OC^2 = (6.8)^2 + (14)^2}$**; OC = 15.6 m.**
- Photograph « *object3* »: $\mathbf{OC^2 = (4.4)^2 + (14)^2}$**; OC = 14.7 m.**

- For configuration « c » :

- Photograph « *object1* »: $\mathbf{OC^2 = (13.8)^2 + (28)^2}$**; OC = 31.2 m.**
- Photograph « *object2* »:$\mathbf{OC^2 = (16.8)^2 + (36)^2}$**; OC = 39.7 m.**
- Photograph « *object3* »:$\mathbf{OC^2 = (10.7)^2 + (36)^2}$**; OC = 37.6 m.**

d- Speed calculations

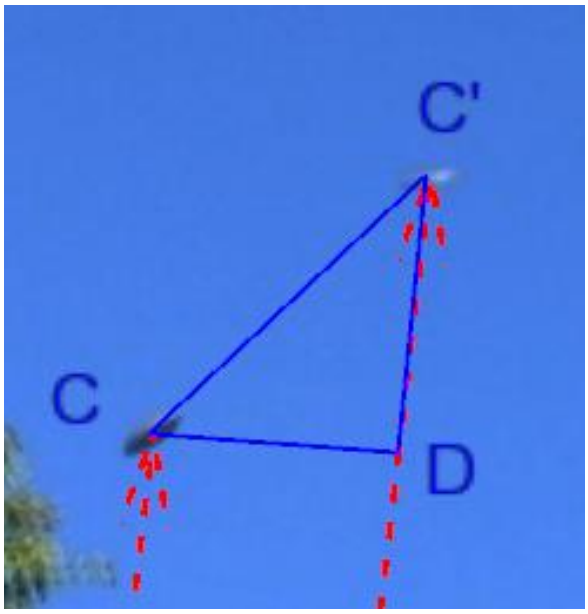
As the object in «*object2*» and «*object3*» photographs is located in the same sequence, we can try to estimate its linear transverse velocity.

The accuracy of the time difference that separates the two pictures is low, the metadata assigning a value of 1 second. This, in the lack of information in tenths of seconds, forces us to consider the maximum possible lapse of time, which ranges from **0.5 s to 1.5 s.** (Between 0 and 0.4 s, there would not have been any difference in the metadata, and between 1.6 s and 2.4 s, the difference would be of 2 seconds)

We have at first to determine the metric value of the actual movement of the object between its two positions on these two images.

First step is do a precise registration of the two photographs « *object2* » and « *object3* », using the IPACO tool "*3 points registration*" using three fixed landscape reference points.

Then we take the horizon line as determined in the previous chapter, materialize the respective altitude of the object in its two successive positions and mark out the right-angle triangle DCC' with C as the position of the object on photograph « *object3* », C' the position of the object on photograph « *object2* » and D the orthogonal projection of C position on the straight line that materializes the altitude of the object in C':



Knowing the DC' value, (which corresponds to the value of the altitude of the object in C' deducted from the value of its altitude in C: **6.1 mfor configuration « c »** and**2.4 m for configuration « z »)**, we can deduce the CC' value, which can be determined either graphically with IPACO or through a quick trigonometric calculation.

We obtain in all cases **CC' = 8.3 m** for configuration « c » and **3.3 m** for configuration « z ».

Then, the object moved from C to C' of **8.3 m** or **3.3 m** in a time between **0.5 and 1.5 s** which corresponds to a **speed comprised between 19.8 and 59.8 km/h (5.5 to 16.6 m/s) for configuration « c » and between 7.9 and 23.7 km/h (2.2 to 6.6 m/s) for configuration « z ».**

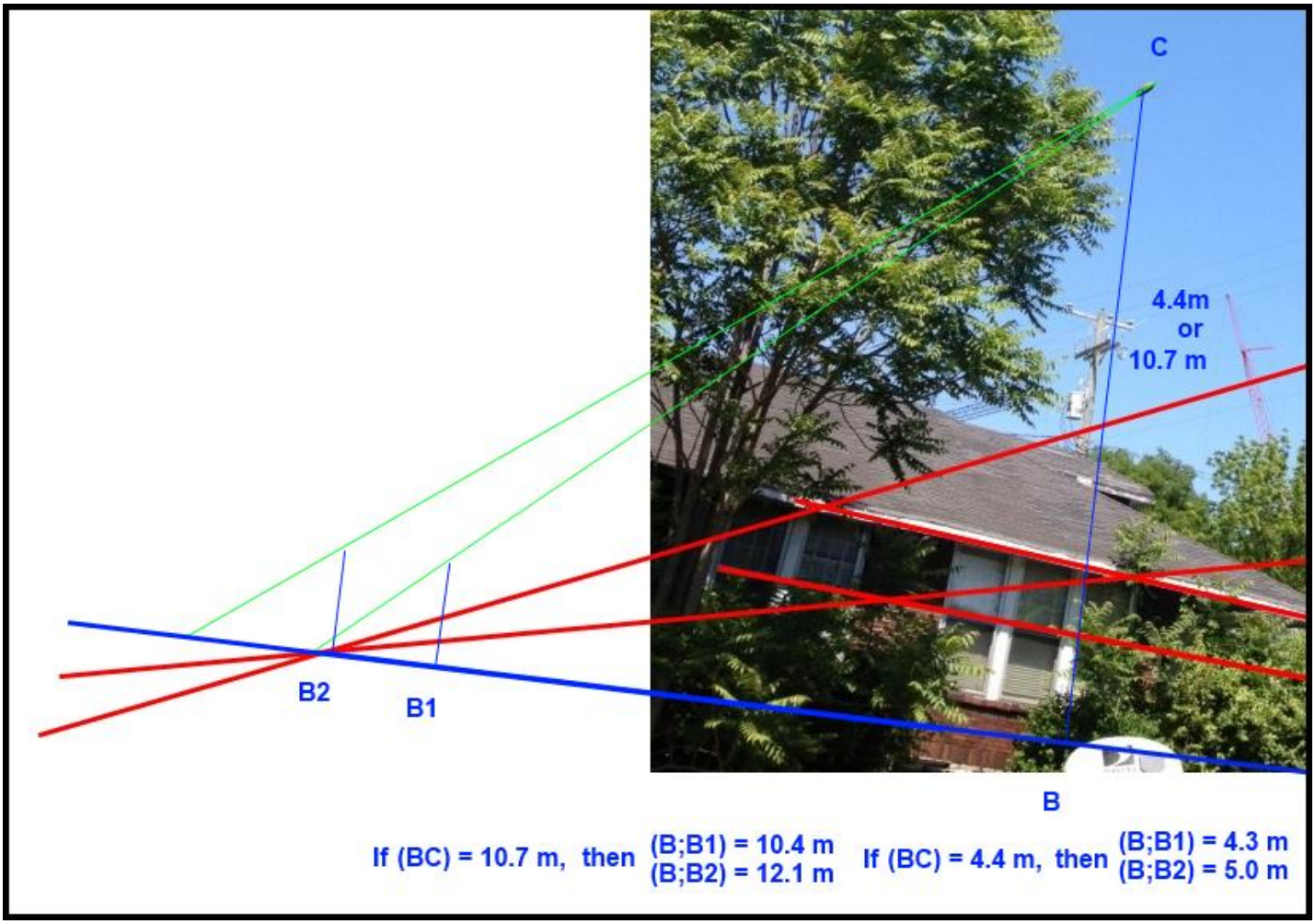
e- Possible positions of the pitcher

The object in photograph « *object3* » is assigned with a certain angle relative to the ground that could be called « *upward angle* », as this photograph has probably been taken at the time of the ascent.

If the object is a « Frisbee-style » object, as its appearance on all pictures seems to suggest, it was launched from the ground at a precise angle that it kept throughout its flight.

Indeed, the combined effect of lift and gyroscopic momentum allows the object to keep its trajectory, speed and stability when moving. Thus, it resists direction changes, acceleration and braking thanks to its rotation.

Since the angle is stable, it should be possible to reconstruct the trajectory of the object as well as its launch point. In order to do this, we take again the previous determination of the horizon line (see chapter b) and reproduce the following points on the diagram below:



- Elevation of the object above ground level (BC): **10.7 m or 4.4 m.**
- Plot of the lines materializing the inclination of the object and extension of these lines up to the horizon line (green lines). These two straight lines are different depending on whether one considers the angle of inclination as defined on the object by its shape or by its own shadow.
- Considering that the launcher is a man with a size of 1.7 m and that the object is dropped from this elevation, its position in the ground in each case is seen, respectively in B1 and B2.
- Finally, we measure the distances (B; B1) and (B; B2).

These two measurements represent the distance between the position of the object in its orthogonal projection on the ground and the position of the launcher.

Now, there's nothing for it but to report these positions of the ground plan (black shaded area):

- Configuration « c » :

The suggested area where the launcher was standing was probably either at the staircase or along the street near the bins.

We can note that the sky is clear and that only one wire is visible above these positions.

- Configuration « z » :

In this configuration, the presumed area where the launcher was standing is probably at the background part of the courtyard, after the tree visible at the leftmost part of the photographs (also shown above to the right of the circled area).

It should be noted that this area is inside the “G/G1” area, already defined in chapter a, and that it is out of sight of the photographer.

f- Summary of the obtained results through the geometric approach

Under the hypothesis that the object is small, we get the following results:

- For a 50 cm diameter object:

- Distance to the photographer: **31.2 m** for photograph « *object1* », **39.7 m** for photograph « *object2* » and **37.6 m** for photograph « *object3* ».
- Altitude: **13.8 m** for photograph « *object1* », **16.8 m** for photograph « *object2* » and **10.7 m** for photograph « *object3* ».
- Speed: **between19.8 and 59.8 km/h (5.5 m/s to 16.6 m/s).**

- For a 20cm diameter object:

- Distance to the photographer: **12.3 m** for photograph « *object1* », **15.6 m** for photograph « *object2* » and **14.7 m** for photograph « *object3* ».
- Altitude: **5.4 m** for photograph « *object1* », **6.8 m** for photograph « *object2* » and **4.4 m**f or photograph « *object3* ».
- Speed: **between 7.9 and 23.7 km/h (2.2 to 6.6 m/s).**

g- Compatibility of the hypothesis with the results

A disc-shaped object with a 26 cm diameter and weighing less than 200 g («*Frisbee*») can fly at average speeds of 14 m/s (50.4 km/h) and travel distances over 100 m.

About the altitude, tests have shown that such an object launched by an adult male could easily reach an altitude of at least 20 m.

Both computed parameters, altitude and speed, are within expected parameters for a light discoid object thrown in the air.

However, these results should be counterbalanced in configuration « c » in relation to the estimated size of the object (50 cm), almost twice that of a conventional Frisbee, which makes it less convenient to be thrown.

In addition, its weight, possibly more important than such a Frisbee model, especially if it is made of metal as its appearance in the pictures seems to suggest, could be a handicap to reach a 16.8 m altitude.

The actual maximal altitude and speed reached are probably lower, but remain nonetheless consistent with those determined for the object, which are not excessive.

Moreover, an Internet search shows that there are many large Frisbee models (12'', 18'' and 24'', respectively 30, 46 and 61 cm diameter) with various colors; we cannot therefore exclude that such a model may have been used.

24'' diameter Frisbee

The results obtained in configuration "z" are however all completely compatible with the launch of a small (about 20 cm in diameter) model from a specific area of the courtyard defined in the previous chapters and being out of sight.

IV. Conclusion

Through the previous chapters, it has been determined, using two very different approaches (radiometric and geometric), that the characteristics of the object photographed three times was compatible with the hypothesis of a small object, having the appearance and behavior of a discoid " Frisbee " style .

The results of the radiometric analysis show that the object was at a distance from the camera of **between 15 and 20 meters** and that consequently its diameter was comprised **between 21 cm and 28 cm.**

The results of the geometrical analysis show that, for a **20 cm diameter**, it was at a distance of **between 12.3 m and 15.6 m** from the camera and at an altitude comprised **between 4.4 m and 6.80m.**

Both results are very similar and support the hypothesis of a ***small object with a diameter of about 20 cm photographed approximately 15 m away***, for the first image.

An estimate of speed was also calculated (**between 7.9 and 23.7 km/h**) and one **possible launch area** (from an easily accessible place outside the field of view of the camera).

This case is classified as «B», photographs of a small disk-shaped "Frisbee-style" object.

V. Sources – Photos credits - Acknowledgments

The case is presented and discussed by the witness in the forum "Above Top Secret", the 2012 April, 11.