The Santa Ana Photographs

(François Louange, Antoine Cousyn and Geoff Quick)

On August 3, 1965, at approximately 12:30 p.m., Rex Heflin, an Orange County (California) traffic inspector, stopped his work truck to photograph a road sign obscured by tree branches. He stated that he then observed a silver object flying slowly from left to right, which he initially took to be an experimental aircraft. Heflin photographed it with his Polaroid Model 101 camera loaded with 3000 ASA film: first through his windshield while the object appeared stationary, then a second and third time through the passenger-side window after observing a beam of light emerging from the object, which seemed to oscillate and then disappeared, leaving behind a smoke ring that he photographed after stepping out of his truck.

Heflin's earliest known statement regarding this incident was made on September 18, 1965, to Edward Evers (NICAP[1]/LANS).

The main studies subsequently conducted were:

- 1968: The Condon Report (Case 52), which discusses the photo sequence, practical tests, and the possibility of a small nearby object: see here.

- Mid-1970s: Ground Saucer Watch (William Spaulding) classified the Heflin photographs as either a hoax or a photographic anomaly. Later sources attributed to Spaulding the identification of a line that could correspond to a suspension wire.

- 2000: A reanalysis of the Heflin photographs by Ann Druffel, Robert M. Wood, and Kelson revisited the historical chain of events, criticized the wire/suspension interpretation, reexamined the photographs, and restored greater importance to earlier documents, including the 1965 statement and the work of McDonald: see here.

- 2006: "Goodbye, Rex Heflin", by Ann Druffel, reviewed the history of the case, the camera and film used, as well as the successive debates surrounding the four photographs: see here.

- Skeptical analyses have also been published, mentioning a small object possibly attached to a wire, notably by Robert Sheaffer: see here.

The purpose of the present document is to examine whether Heflin's four photographs — for which excellent TIFF scans were kindly made available to us by the Druffel family, whom we thank — are consistent with the account of an airborne object several meters in size, or whether they are better explained by a small object located close to the camera, possibly suspended.

[1] NICAP file on August 3, 1965: see here.

Photo H_1

Photo H_2

Photo H_3

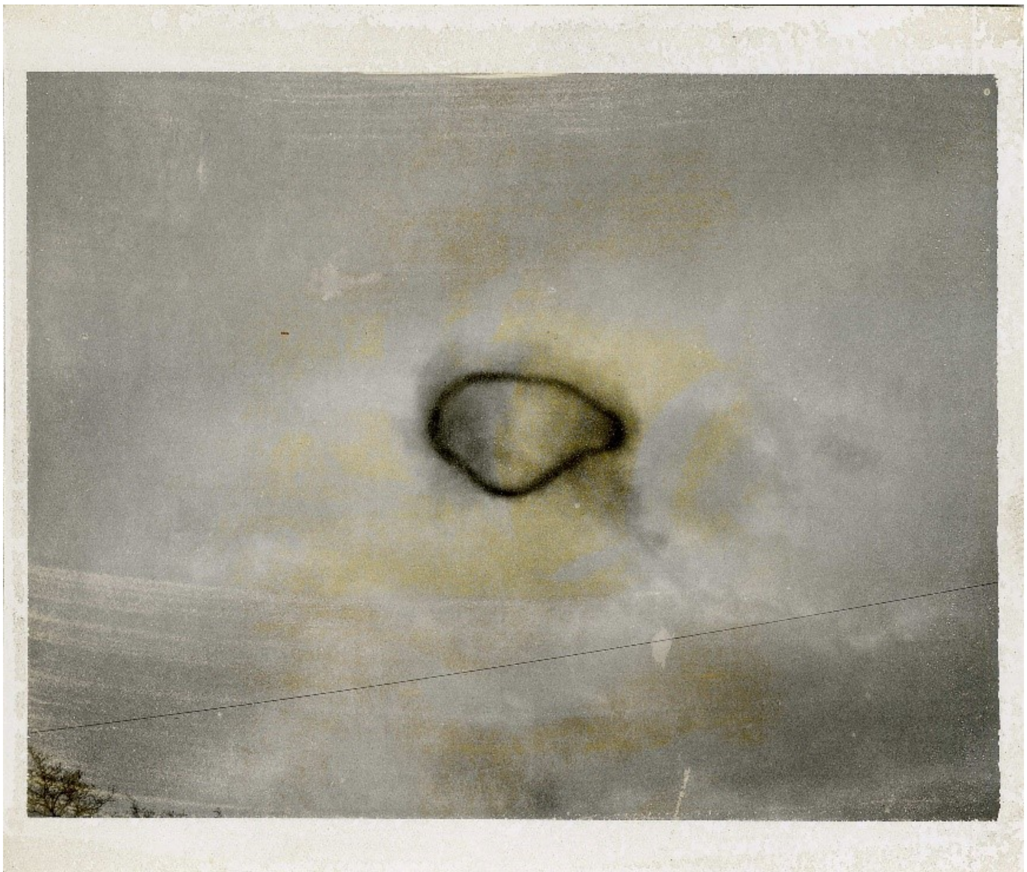


Photo H_4

Camera and settings

Camera model:	Polaroid Model 101 semi-automatic
Photo size:	3.25 × 4.25 inches (8.255 × 10.705 cm)
Focal length:	114 mm
Aperture:	f/42 (fixed value for 3000 ASA film)
Exposure time:	unknown (variable from 10 s to 1/200 s)
Film speed:	3000 ASA

Technical documentation for the Polaroid model 101: see here.

Data preparation

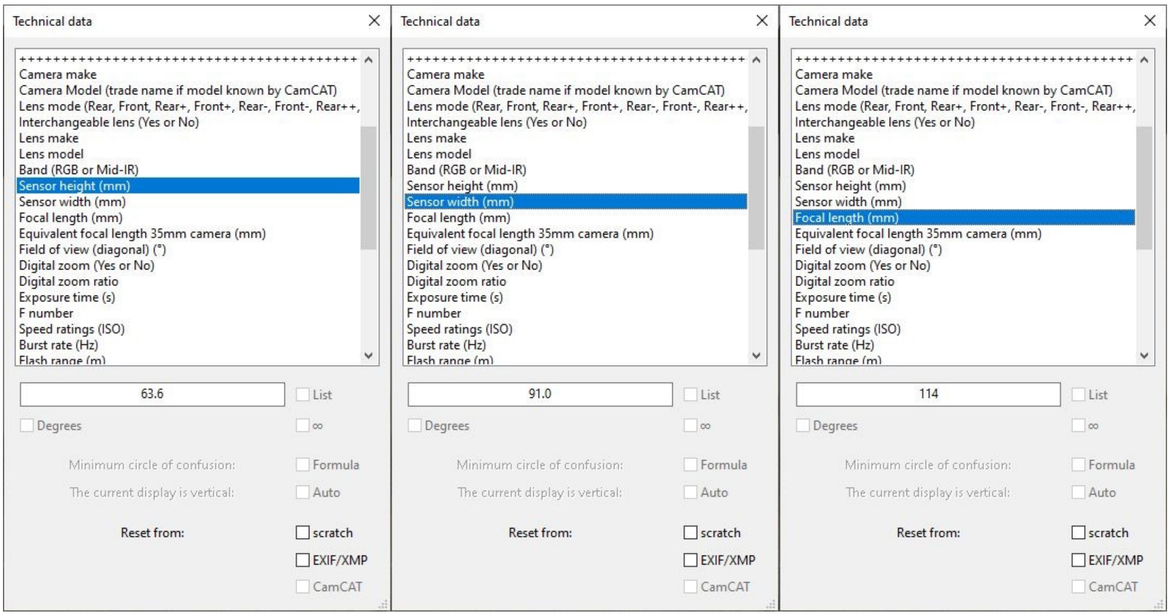
We begin by importing images $\mathbf{H_1}$ through $\mathbf{H_4}$ into our dedicated **IPACO** software tool, then activate the ***Camera/Technical Data*** function in order to enter the parameter values required for the angular measurements.

The focal length is known (**114 mm**), as are the physical dimensions of the photographs (8.255 × 10.705 cm). However, these dimensions include the white borders surrounding the image area corresponding to the camera's sensitive surface ("sensor" in IPACO terminology). To determine the actual dimensions of this surface, the "useful" width and height fractions must be measured precisely on the photographs. These measurements were made using IPACO's ***Local Geometric Mensuration*** function.

Since the pixel dimensions of the four photographs differ slightly, only average values can be used:

- Height : sensor/image fraction ≈ 0.77
- Width : sensor/image fraction ≈ 0.85

The resulting "sensor" dimensions taken into account are therefore: **6.36 × 9.10 cm**.



Geometric analysis

This section concerns only the first three photographs, which show a well-defined object. The fourth photograph, which is very different, will be discussed separately.

The first step of the analysis consists in measuring the angular size of the object in the first three photographs (**H_1**, **H_2**, and **H_3**) and deducing a length-to-distance ratio from it.

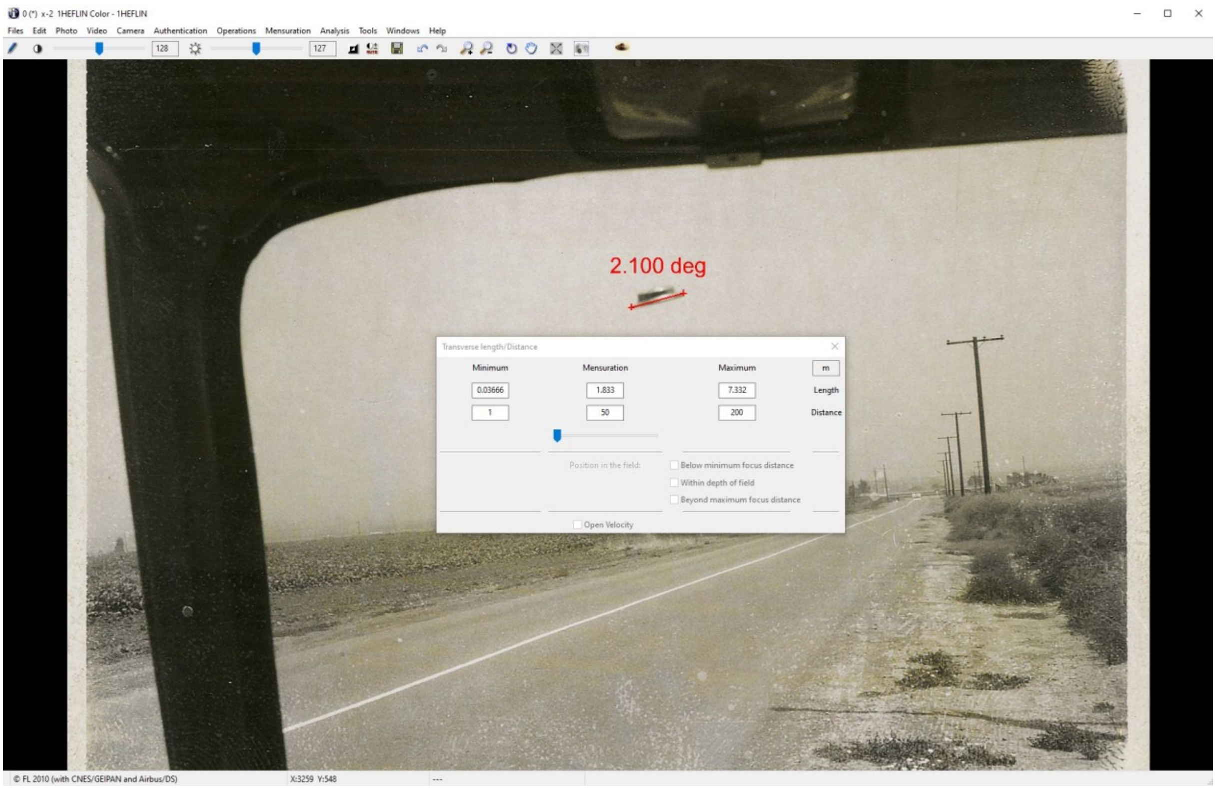


Photo H_1

Photo H₂

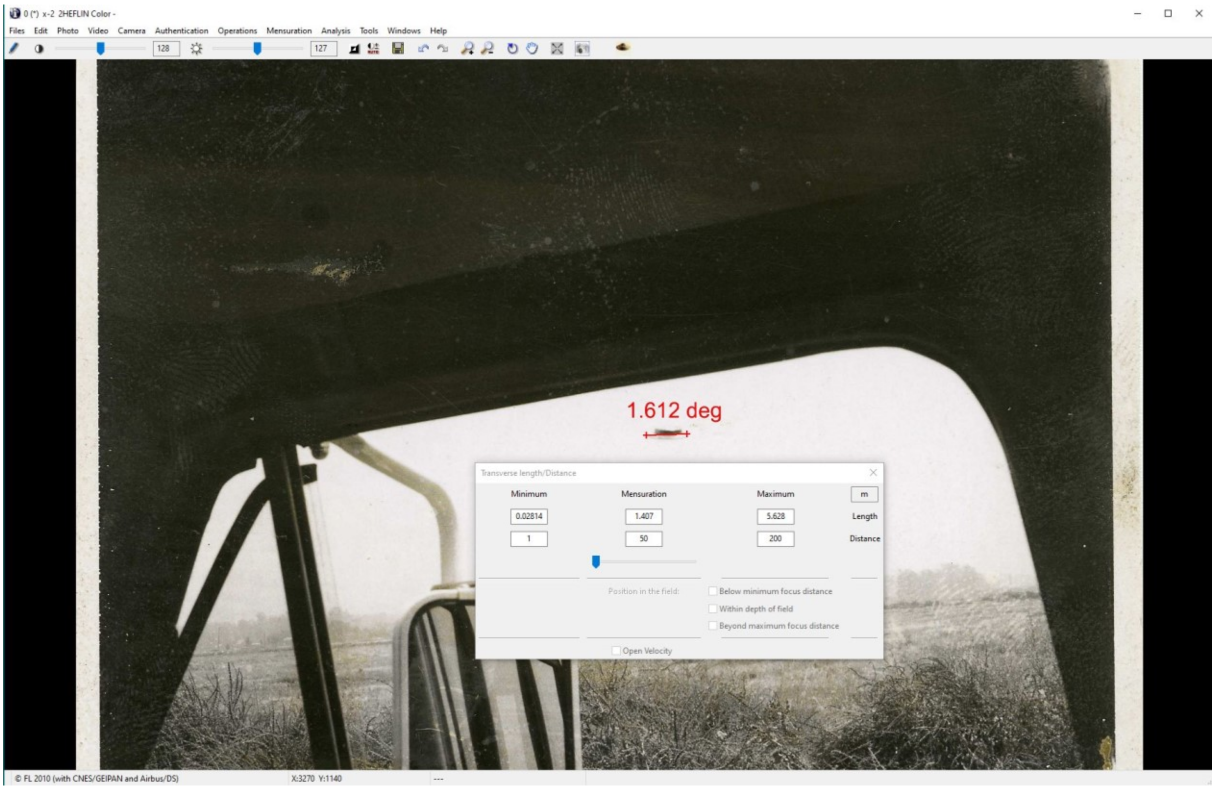


Photo H₃

The ratios between the object's length and its distance from the camera, for each of the three photographs, are provided by IPACO's ***Length vs Distance*** function:

	Photo H_1	**Photo H_2**	**Photo H_3**
Length/Distance	0.037	0.026	0.028

The following table presents, for each of the three photographs, the object's length in meters as a function of an assumed distance:

Distance (m)	**Photo H_1**	**Photo H_2**	**Photo H_3**
1	0.037	0.026	0.028
2	0.073	0.053	0.056
5	0.18	0.13	0.14
10	0.37	0.26	0.28
50	1.8	1.3	1.4
100	3.7	2.6	2.8
200	7.3	5.3	5.6

More meaningfully, the following table presents, for each of the three photographs, the object's distance in meters as a function of an assumed length:

Length (m)	**Photo H_1**	**Photo H_2**	**Photo H_3**
0.01	0.27	0.38	0.36
0.02	0.55	0.76	0.71
0.05	1.4	1.9	1.8
0.1	2.7	3.8	3.6
0.5	14	19	18
1.0	27	38	36
2.0	55	76	71
5.0	140	190	180

Several conclusions can already be drawn from these tables:

- Assuming that the object had a constant actual size and a comparable outline in the three images, the apparent distance derived from the angular measurements changes from one photograph to the next:

  If this distance is equal to **D** for photo **H_1**
  it becomes **1.4 D** for photo **H_2**
  and **1.3 D** for photo **H_3**.

- The length-to-distance ratio calculated from Rex Heflin's estimates for photo **H_1** is of the same order of magnitude as the result presented above (**0.037**), and is therefore reasonably accurate within the uncertainties involved:

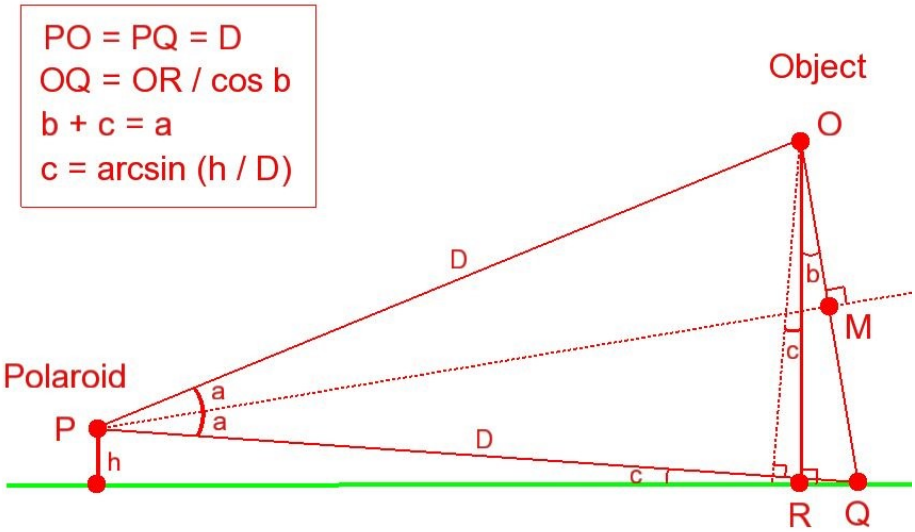
  Estimated distance: "1/8 mile", i.e. D = 201 m
  Estimated size: "20 feet", i.e. 6.10 m
  => Heflin's length-to-distance ratio = **0.030**

- On the other hand, Heflin's estimate of the object's height above the ground (H = 150 feet, i.e. 45.7 m) is incompatible with his estimate of the object's distance and therefore its size, in all three photographs.

This is illustrated in the following images, which represent the height **H** of the object above the ground assuming it was actually located 201 m from the camera in photograph $\mathbf{H_1}$, and therefore at (1.4 × 201) = 281 m in photograph $\mathbf{H_2}$, and at (1.3 × 201) = 261 m in photograph $\mathbf{H_3}$.

It is assumed that this height H (45.7 m) remained approximately constant throughout the three photographs, and that Heflin kept his camera approximately horizontal (within about ±5°).

The calculation is based on the following diagram, drawn in the vertical plane passing through the Polaroid Model 101 camera P and the object O:



In this diagram:

D = PO = PQ = distance between the object and the Polaroid camera
h = height of the Polaroid camera above the ground
OR = height of the object above the ground

The height h cannot be determined precisely, since neither the dimensions of the truck nor Rex Heflin's height are known. It may reasonably lie within a range of 1.3 m to 1.9 m, and we shall use the average value of 1.6 m, with an uncertainty of 0.3 m.

The calculation is performed through successive approximations:

1. Calculation of the angle c = arcsin(h/D)
2. Intuitive selection of a value for angle a
3. Calculation of angle b = a - c
4. Calculation of PM = D cos a
5. Using IPACO's ***Angle*** function, drawing on the photograph a segment corresponding to an angle equal to 2a, from the center of the object vertically downward
6. From this angle, activation of the ***Length vs Distance*** function by entering a "Distance" equal to PM and obtaining a "Length" equal to OQ
7. Calculation of OR = OQ cos b
8. If OR = H (estimated height of the object above the ground, i.e. 45.7 m), the calculation ends and the vertical segment associated with angle "2a" is validated. Otherwise, return to step 2 with a new value of a, and iterate until **OR = H** is satisfied.

The position of the object's vertical projection onto the ground is indicated in each photograph by an ellipse.

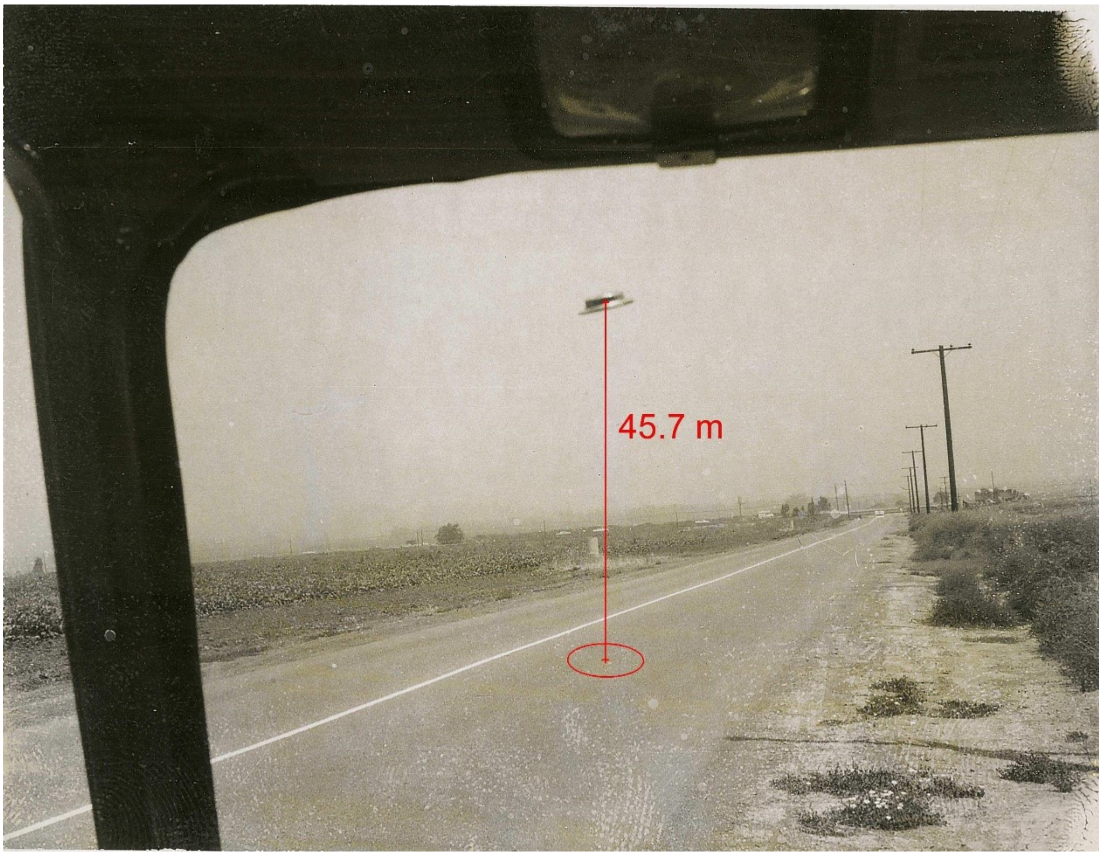


Photo H_1: angle 2a = 13.15°, distance D = **201 m**, height H = **45.7 m**

Photo H_2: angle 2a = 9.37°, distance D = 1.4 × 201 = **281 m**, height H = **45.7 m**

Photo H_3: angle 2a = 10.10°, distance D = 1.3 × 201 = **261 m**, height H = **45.7 m**

*<u>Sensitivity to variations in the camera height **h** (Photo **H_1**)</u>*

If h = 1.3 m, the angle 2a changes from 13.15° to 13.13°
If h = 1.9 m, the angle 2a remains equal to 13.15°

The positional variations of the ellipses are barely detectable over the entire possible range of values for h, showing that the results are only weakly sensitive to this parameter.

For all three photographs, the modeling leads to a ground projection that appears much closer to the truck than suggested by the witness's estimated distance.

To quantify this impression, it is possible to estimate in each photograph the distance between the ellipse and the camera, using the horizon line (drawn in green below).

This distance **d** is given by the following formula:

$d = (R + h) \sin A - \sqrt{[R^2 - (R + h)^2 \cos^2 A]}$ with :

R = mean radius of the Earth ≈ 6 371 km
h = height of the Polaroid camera above the ground
A = angle of depression (observation angle below the horizon)

The horizon is drawn very carefully on the photographs, but there still remains an uncertainty of about 0.3° in the value of angle A.

Following the calculations below, a sensitivity study will show the actual influence of the uncertainties in h and A on the resulting value of d.

The following three images show the value of angle A measured on each photograph.

Photo H_1

Photo H_2

Photo H_3

The formula used to calculate the distance **d** between the Polaroid camera and the ellipse, representing the object's orthogonal projection onto the ground, gives the following results:

Photo	Angle A	**d**
H_1	4.863°	18.8 m
H_2	2.517°	36.5 m
H_3	3.063°	29.9 m

*Sensitivity to variations in the camera height **h***

If h = 1.3 m, the table becomes:

Photo	*Angle A*	***d***
H_1	*4.863°*	*15.3 m*
H_2	*2.517°*	*29.7 m*
H_3	*3.063°*	*24.4 m*

If h = 1.9 m, the table becomes:

Photo	*Angle A*	***d***
H_1	*4.863°*	*22.4 m*
H_2	*2.517°*	*43.2 m*
H_3	*3.063°*	*35.6 m*

<u>Sensitivity to variations in the horizon line placement</u>

If A is reduced by 0.3°, the table becomes:

Photo	*Angle A*	***d***
H_1	*4.563°*	*20.1 m*
H_2	*2.217°*	*41.4 m*
H_3	*2.763°*	*33.2 m*

If A is reduced by 0.3°, the table becomes:

Photo	*Angle A*	***d***
H_1	*5.163°*	*17.8 m*
H_2	*2.817°*	*32.6 m*
H_3	*3.363°*	*27.3 m*

It can be seen that the tested variations in parameters h and A modify the numerical values, but their effect does not change the order of magnitude of the distance d.

It follows that if Heflin genuinely observed an object in the air, he was mistaken in his estimates concerning photograph H1: either the object's distance was substantially less than 201 m, and therefore its size substantially less than 6.1 m, or its altitude was substantially less than 45.7 m, with the error factor being at least on the order of 10 in either case.

At this stage of the analysis, it should be recalled that an error of estimation by a witness does not in itself prove that a hoax necessarily took place.

However, in the present case, an error factor on the order of 10 or greater would mean either that the object's distance was less than 20 m and therefore its size less than 61 cm, or that the object's height above the ground was less than 4.6 m.

In both cases, the credibility of the witness's estimates becomes very difficult to sustain.

Radiometric analysis

This section presents an attempt to analyze the radiometric properties of the photographs by examining the grayscale level of the pixels, which is representative of their luminance. Since the original photographs are black and white, we consider only the average of the red, green, and blue levels of the pixels obtained from the digitization process.

Histograms

A histogram shows the distribution of an image's pixels according to their value between 0 (black) and 255 (white). The respective histograms of the three photographs are as follows:

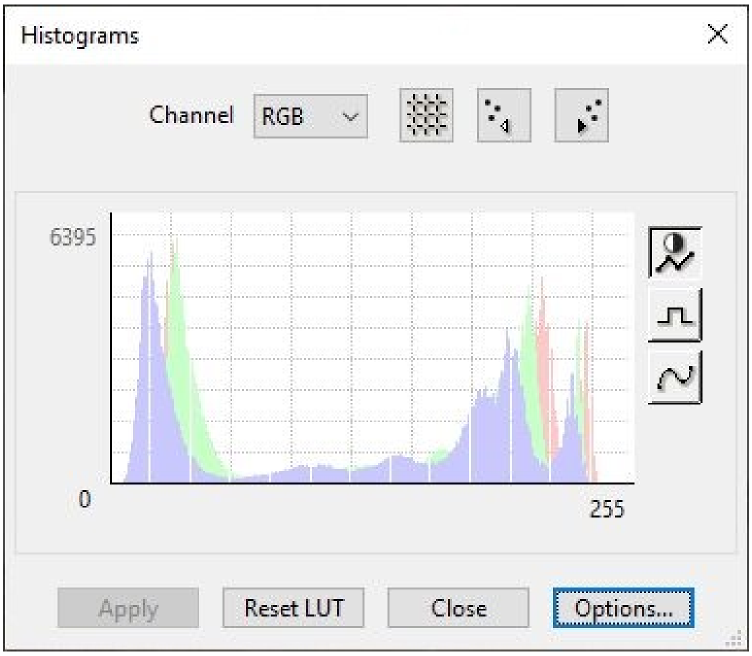


Photo H_1

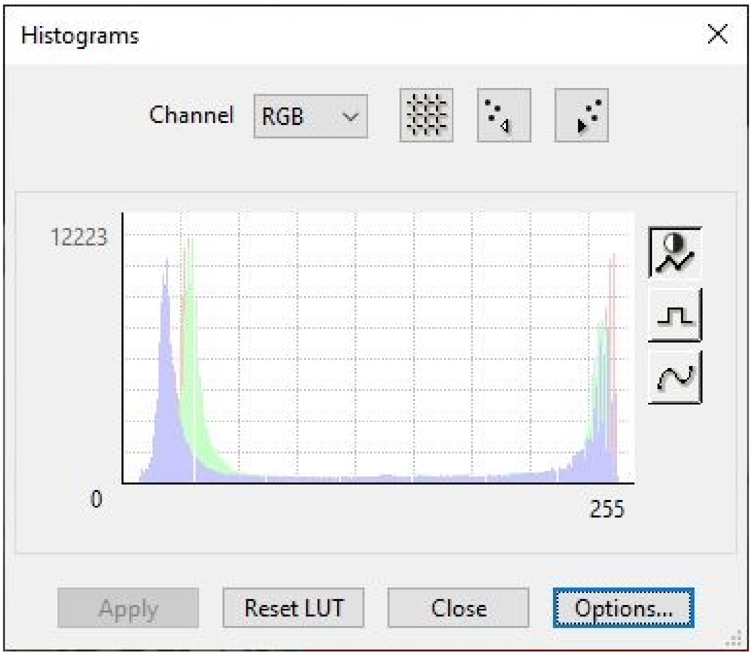


Photo H_2

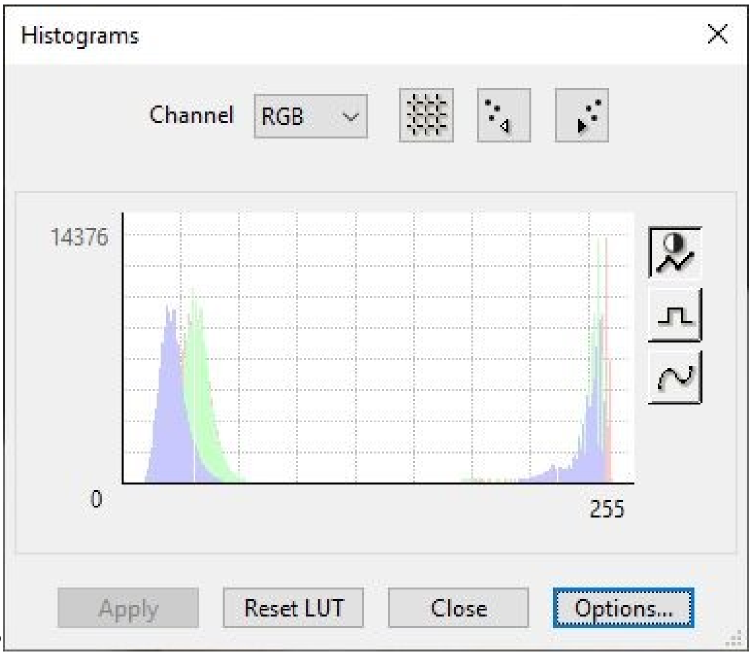


Photo H_3

It should be noted that photographs $\mathbf{H_2}$ and $\mathbf{H_3}$ are globally darker and more contrasted than photograph $\mathbf{H_1}$.

Gray levels

To evaluate possible distances, a standard method consists in attempting to compare the black (or very dark) parts of the image, when such areas exist, since the farther a "black body" is from the camera, the lighter it appears because of atmospheric scattering. More precisely, if the sky luminance is equal to LH, the luminance L of a black body depends on LH, on the distance x from the camera, and on a constant α that depends in particular on the weather conditions, according to the following law:

$$L = (1 - 10^{-\alpha x})\, L_H$$

The upper part of the object is visibly rather bright ("silvery," according to Heflin), and is therefore of no use for an attempted distance evaluation by comparison. On the other hand, the lower part of the object, visible only in photograph $\mathbf{H_2}$, appears very dark ("dark underside," according to Heflin), if not black. It is therefore justified to compare its "grayscale level" with that of other very dark elements in photograph $\mathbf{H_2}$.

IPACO's ***Radiometric Cross-Section*** function makes it possible to visualize variations in grayscale level along an axis chosen by the analyst. We drew an axis crossing all the very dark regions of photograph $\mathbf{H_2}$, including the object under study.

The following image shows that the object's grayscale level is close to that of the nearly black parts of the vehicle (roof, reflections in the rear-view mirror of the truck edges and utility poles, nearby grass), suggesting that the object was not very far away.

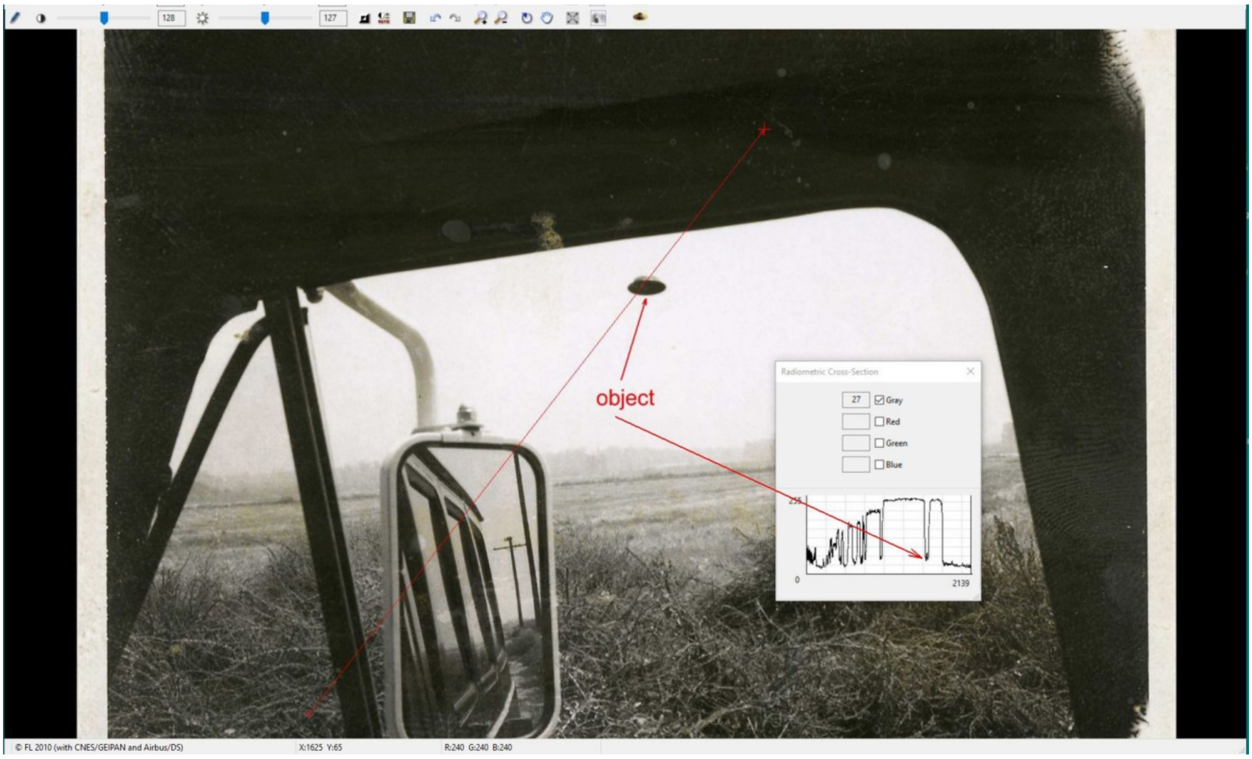


Photo H_2

The ***Area*** function makes it possible to determine the lowest grayscale level within a given region of the image. We can thus determine the darkest point of the object in photograph **H_2**:

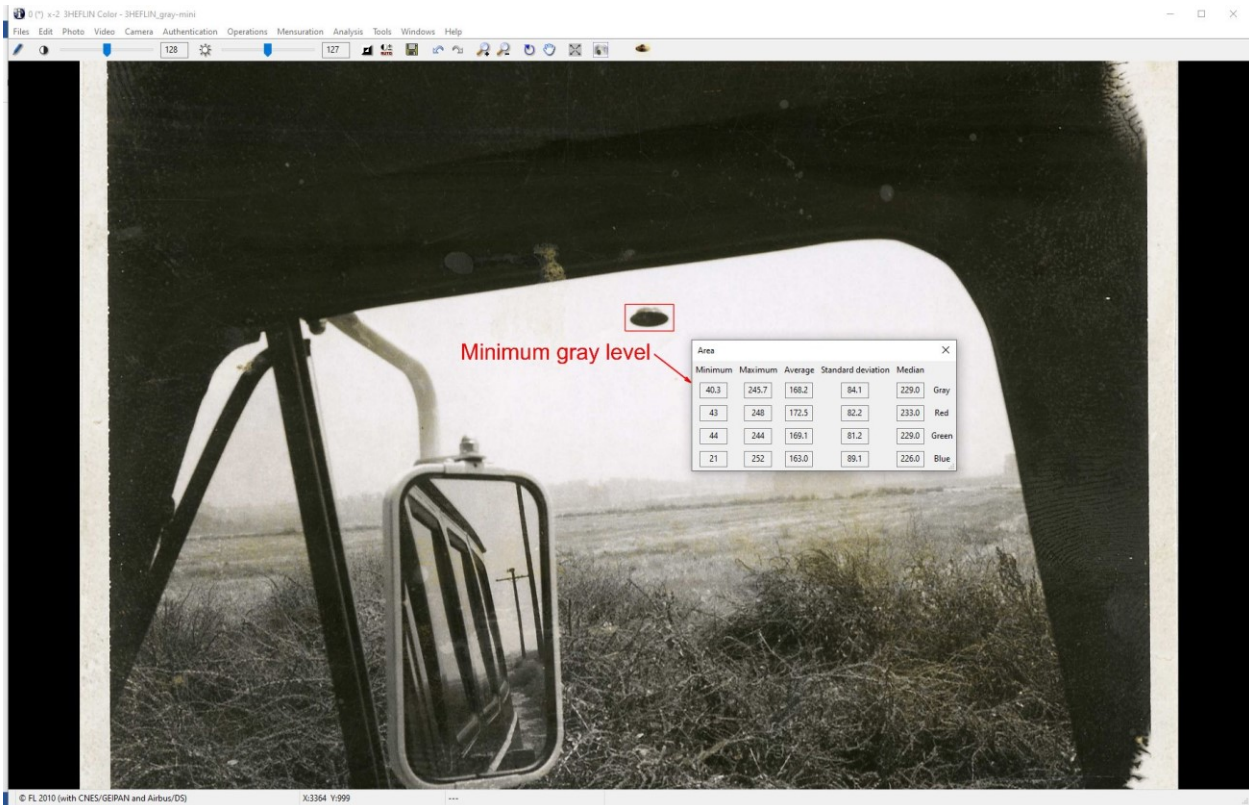


Photo H_2

This darkest point of the object has a grayscale level of **33.3**.

We shall compare this level with the minimum grayscale levels measured in several representative regions corresponding to homogeneous parts of the scene, each delimited by polygons. IPACO's Area function provides the grayscale level of the darkest pixel within each of these regions. In the case of highly "noisy" image areas (a typical example being vegetation), there are statistically always some pixels in shadow and therefore dark, which justifies this approach.

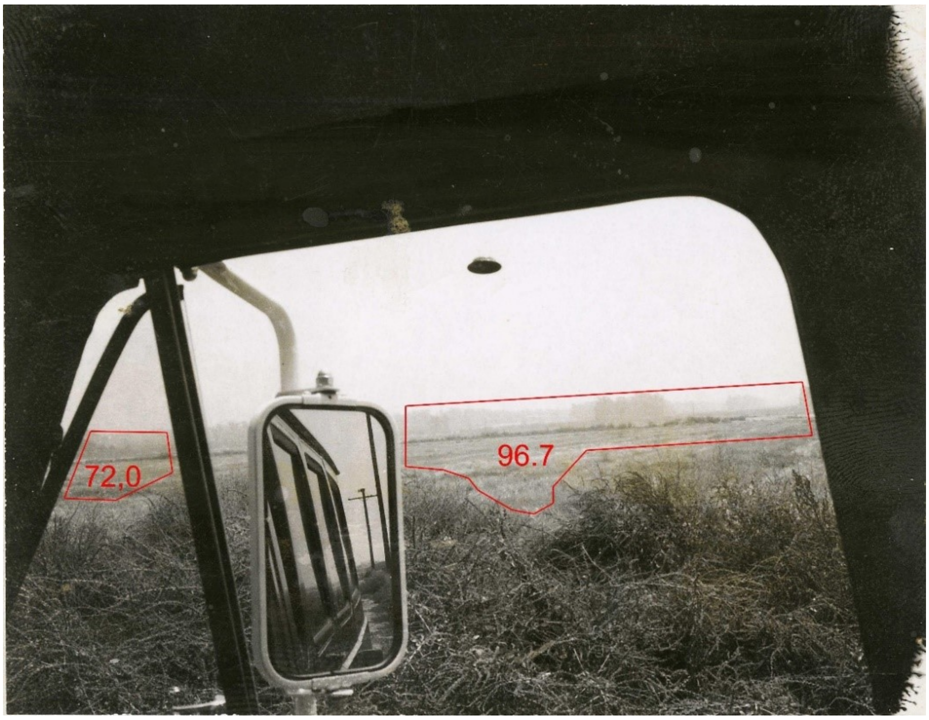
The first image shows a region outlined in red corresponding to the interior of the truck, and therefore located less than one meter from the camera:

The minimum gray level in this region is equal to **0.3** (close to the value 0 for absolute black).

The second image shows two areas of bushes close to the truck:

The minimum grayscale levels of the two regions are equal to **5.0** and **0.3** respectively.

The following image shows two field areas located somewhat farther from the truck:



The minimum grayscale levels of the two regions are respectively equal to **72.0** and **96.7**.

These measurements are therefore consistent with an object located closer than the field background, even though they do not by themselves make it possible to determine an absolute distance.

To illustrate the orders of magnitude involved, one may estimate the distance between the Polaroid camera and a point on the ground included within the field area shown above, using a calculation similar to that presented on page 10 and based on the horizon line (shown in green).

This calculation shows that the point on the ground marked in yellow in the image below is located at a distance of approximately 25 m from the camera, which is far less than the 281 m resulting for photograph $\mathbf{H_2}$ from Heflin's initial estimate, and even far less than the 201 m estimate he gave for photograph $\mathbf{H_1}$. Yet the grayscale level around this yellow point is much higher than that of the object, meaning that the object itself could only have been located at a significantly shorter distance than the yellow point.

This maximum object distance of 25 m would correspond to a maximum object size of 65 cm (see above).

An object whose size is smaller (possibly much smaller) than 65 cm does not match Heflin's description.

As a precaution, it should be recalled that the analyzed image files originate from a processing chain beginning with the original paper photographs, digitized as TIFF files (uncompressed). Unlike the geometric parameters, which remain unchanged throughout this chain, the radiometric parameters may have been altered, making grayscale measurements less reliable.

However, insofar as we are concerned here only with the darkest pixels, it is reasonable to assume that these pixels remained essentially the same throughout the entire processing chain.

This measurement strengthens the credibility of the small-object hypothesis.

Suspension thread

IPACO's ***Vertical Thread*** function is based on an original algorithm specifically designed to reveal a roughly vertical thread in a presumed UFO photograph. A detailed description of the adopted approach can be found in the site's *Analysis Methodology* section, as well as in the IPACO User Manual (***Analysis*** menu).

The basic idea is that if a thread trace exists in the pixels of a photograph, above an object suspended from that thread (or below a tethered balloon), and if this trace is "buried in the noise" corresponding to the sky background (noise caused by atmospheric scattering and/or by the digitization process), it should be possible to increase the signal-to-noise ratio and thereby make the thread stand out by summing the pixels along columns parallel to the thread. It should be noted that this principle makes the tool theoretically ineffective when the sky background does not appear uniform in the region above the object.

To explain and justify the method, let us take as an example one of the power lines visible in photograph $\mathbf{H_1}$ and barely perceptible. The steps are as follows:

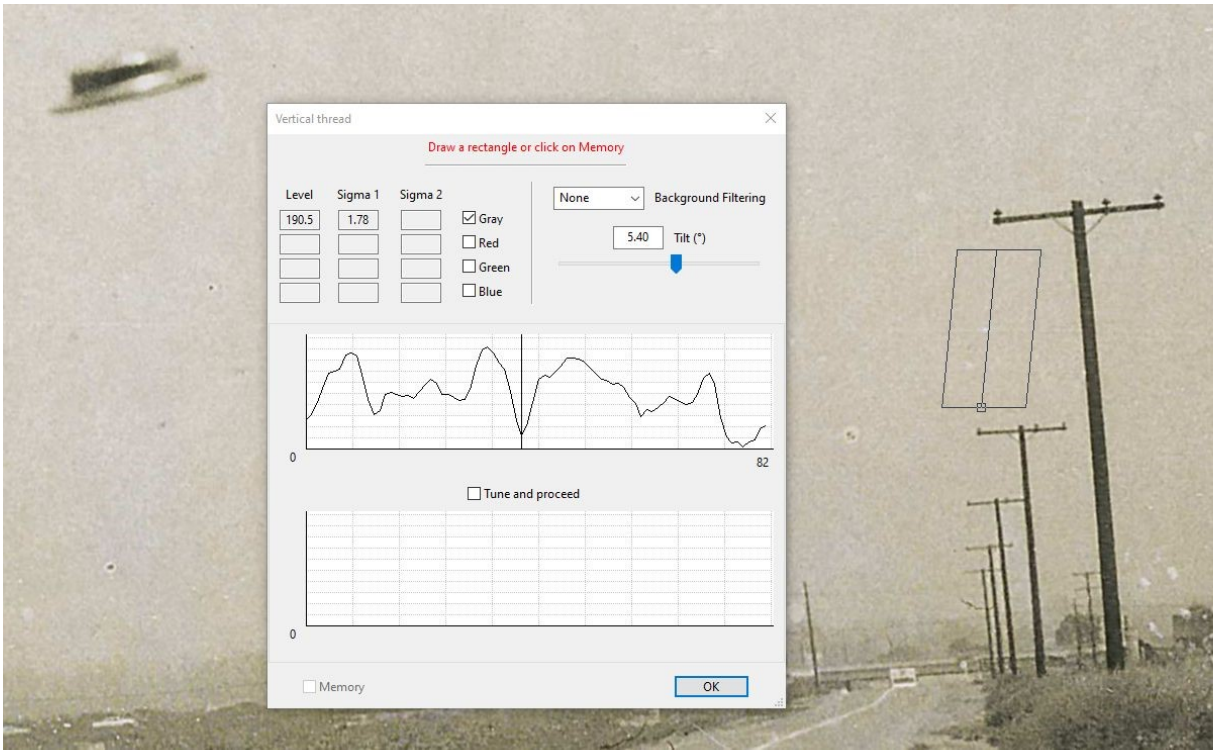
1. Define a vertical rectangle covering the area where the suspension thread may be located, here between the first two utility poles. A window then displays the curve showing the variation of the average pixel value (here in gray) across the columns of the rectangle.

2. Position a cursor on the lower side of the rectangle, near the presumed attachment point of the thread. This position is continuously indicated by a vertical bar on the curve displayed in the window. The average pixel value of the column corresponding to the bar position is continuously displayed, together with the difference between this value and the mean value of the curve, normalized by the standard deviation (number of sigma).

3. Since the thread is rarely perfectly parallel to the vertical axis of the photograph, rotate the rectangle interactively by an angle between −30° and +30° relative to the vertical.

   More precisely, the rectangle is transformed into a parallelogram whose lower side remains fixed and whose height remains constant. The pixel-summation columns are tilted by the same angle, and the curve changes continuously as the angle varies.

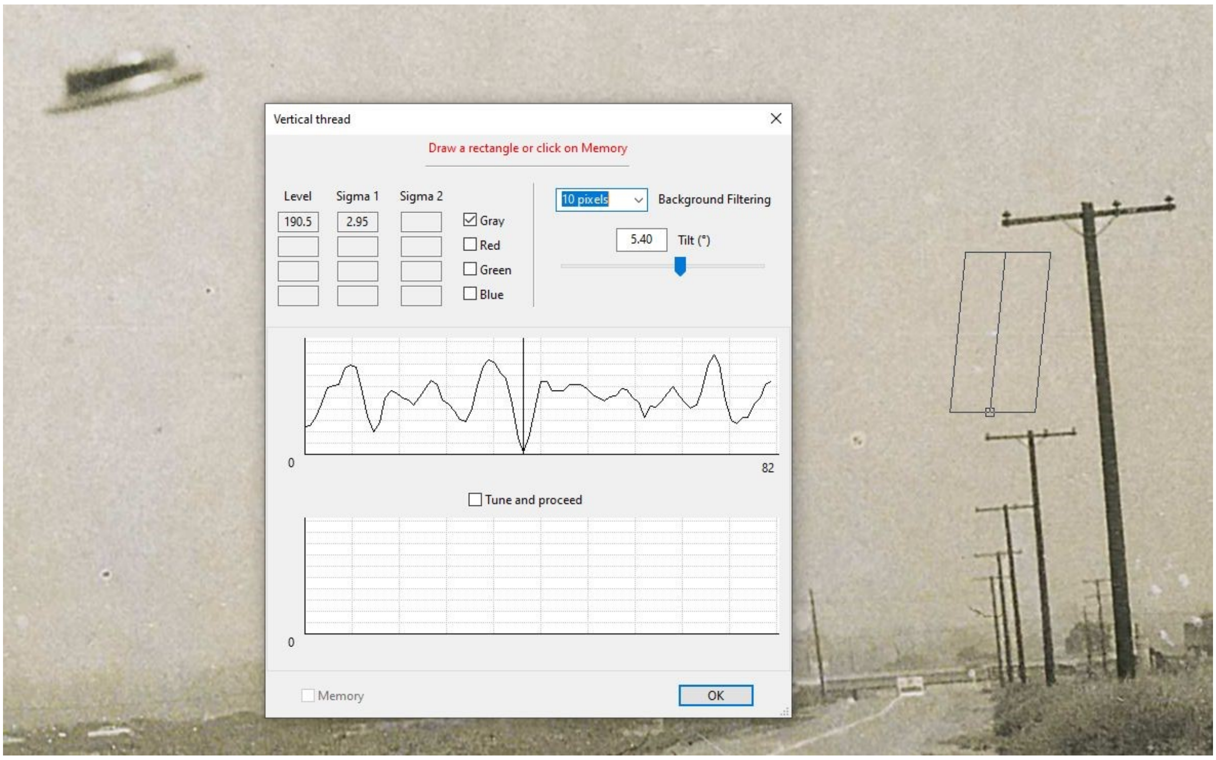
4. Interactively search for an angle value, if one exists, for which a significant peak appears opposite the presumed attachment-point position. The existence of such a peak indicates a probability that a thread is present, with this probability increasing as the difference between the peak and the mean value becomes larger.



In photograph $\mathbf{H_1}$, we observe a very clear negative peak (the thread being darker than the sky) corresponding exactly to the presumed attachment point, with a deviation of 1.78 sigma, for an angle of +5.4°.

5. To eliminate slow variations in the brightness of the sky background, it is possible to apply a high-pass spatial filter to the summation curve. Here, the background is filtered using a window 10 pixels wide, and the deviation reaches 2.95 sigma.

   It should be noted that the use of such a filter modifies the curve, but cannot create a peak that was not already present.



6. At this stage, the software tool makes it possible to launch an automatic optimization procedure in order to refine the angle value and the position of the bar by maximizing the sigma value.

7. A supplementary verification is then performed: starting from the line representing the presumed location of the thread, and from the presumed attachment point on this line, a circular sweep is carried out around this point, while the pixels included in the summation are those contained within the parallelogram. A second curve is displayed in the window, representing the variation of the average pixel value of each column during the sweep.

   If a peak appears for the angle value previously determined (with the bar remaining at the same position), the presence of a thread may be considered reliably demonstrated, especially if the difference between this peak and the mean value of the second curve is significant.

A perfect correspondence between the two peaks is observed for an angle of +6.04°, with deviations greater than 3 sigma. The power line has therefore indeed been detected.

Applying the ***Vertical Thread*** function to the three Heflin photographs yields the following results:

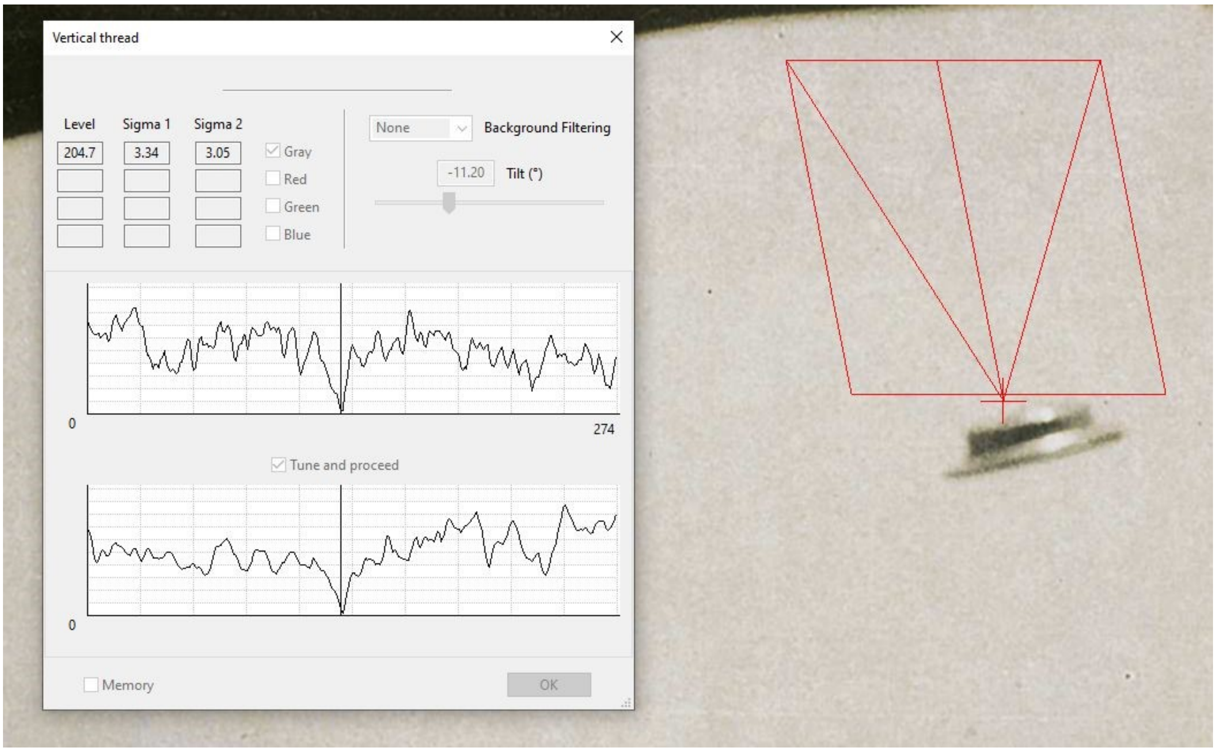


Photo H_1

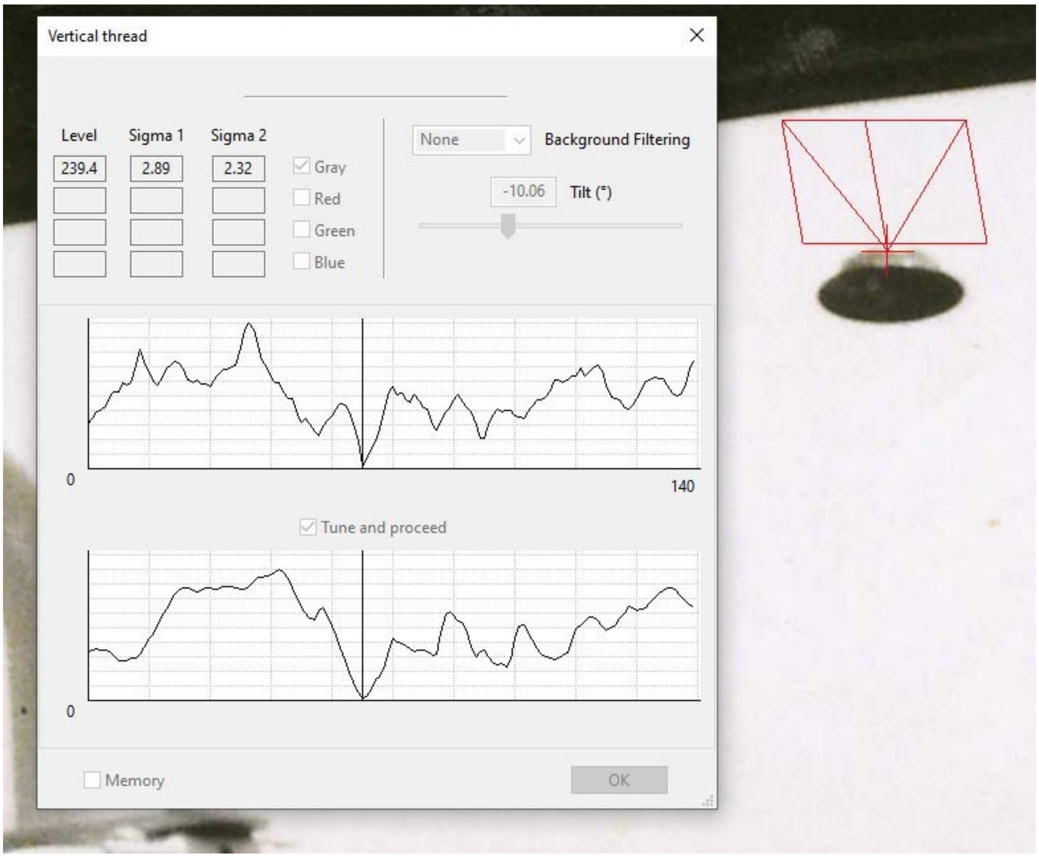


Photo H_2

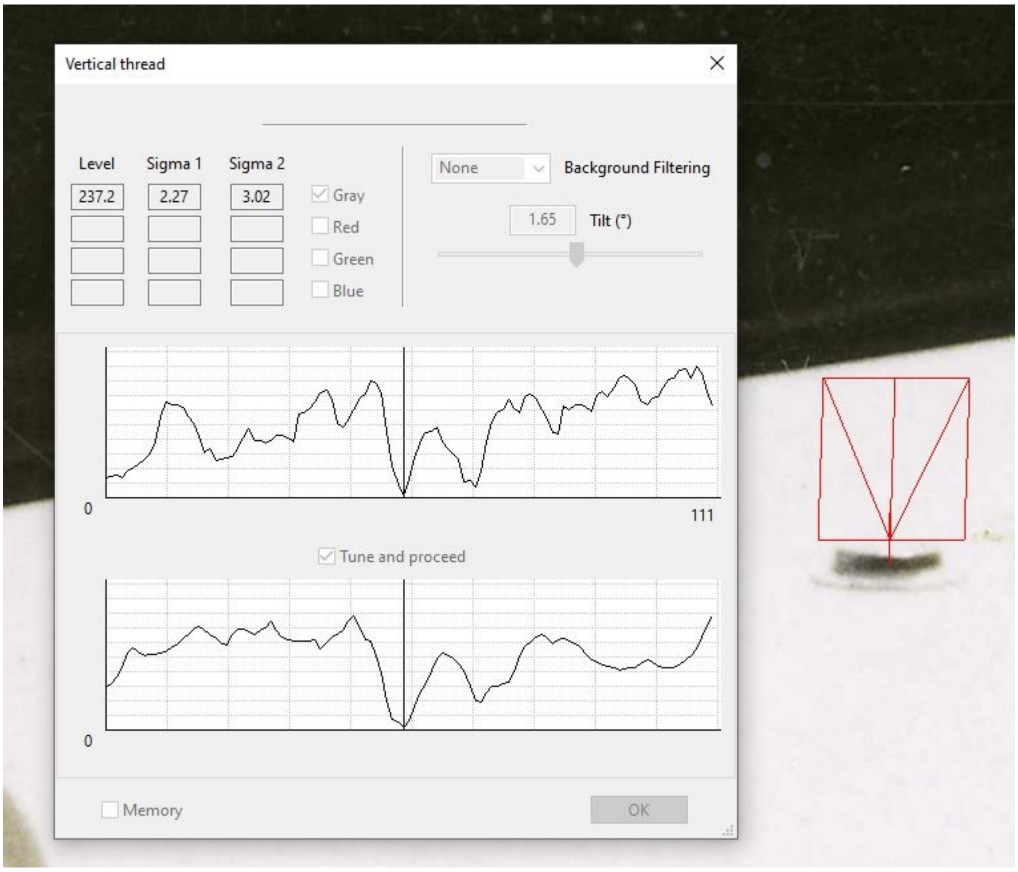
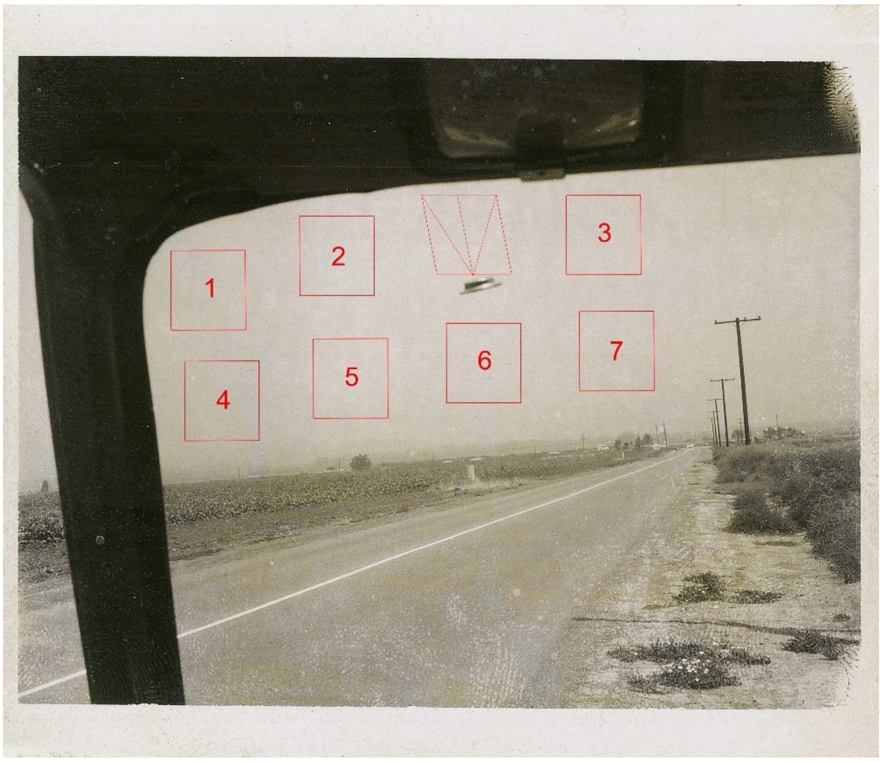


Photo H_3

The clarity of the results observed on the two curves associated with each of the three photographs, together with the coincidence of the negative peaks with the presumed attachment point of the object and the consistency between the orientations of the thread and the object, argue strongly in favor of the validity of the demonstration.

Sensitivity to false positives

*Naturally, this method, which relies on image noise, can sometimes generate "false positives." In photograph **H_1**, we performed the same sequence as described above starting from seven rectangles (numbered) of identical size, and searched for possible "false positives" by scanning all possible angles (from −30° to +30°).*



The results are as follows:

Rectangle n°	**False positive**	**Angle**	**Sigma**
1	*yes*	*+8.3°*	*2.14*
2	*no*	*--*	*--*
3	*yes*	*+28.1°*	*2.77*
4	*no*	*--*	*--*
5	*no*	*--*	*--*
6	*yes*	*-20.4°*	*2.38*
7	*yes*	*0.30°*	*2.61*

It can indeed be observed that false positives occur for certain angles in some cases.

Nevertheless, the probability that a false positive would occur exactly at the location where the suspension thread is expected, with an orientation compatible with that of the object, remains low.

And for this to occur again across three different images, the probability becomes extremely low.

Conclusion for the first three photographs

The results of the geometric and radiometric analyses of the first three photographs have shown that the photographed object must have had a size, a distance from the camera, and a height above the ground far smaller than Rex Heflin's estimates:

Size << 60 cm	instead of 6.1 m
Distance << 20 m	instead of 201 m
Height << 4.6 m	instead of 45.7 m

The object was therefore probably rather small and most likely suspended by a thread attached to the end of a pole.

It remained to determine whether this thread could be detected, and the demonstration above showed that IPACO's *Vertical Thread* function made it possible to establish this with a very high probability.

It follows from the foregoing that **the Santa Ana UFO was very probably a model suspended from a thread**.

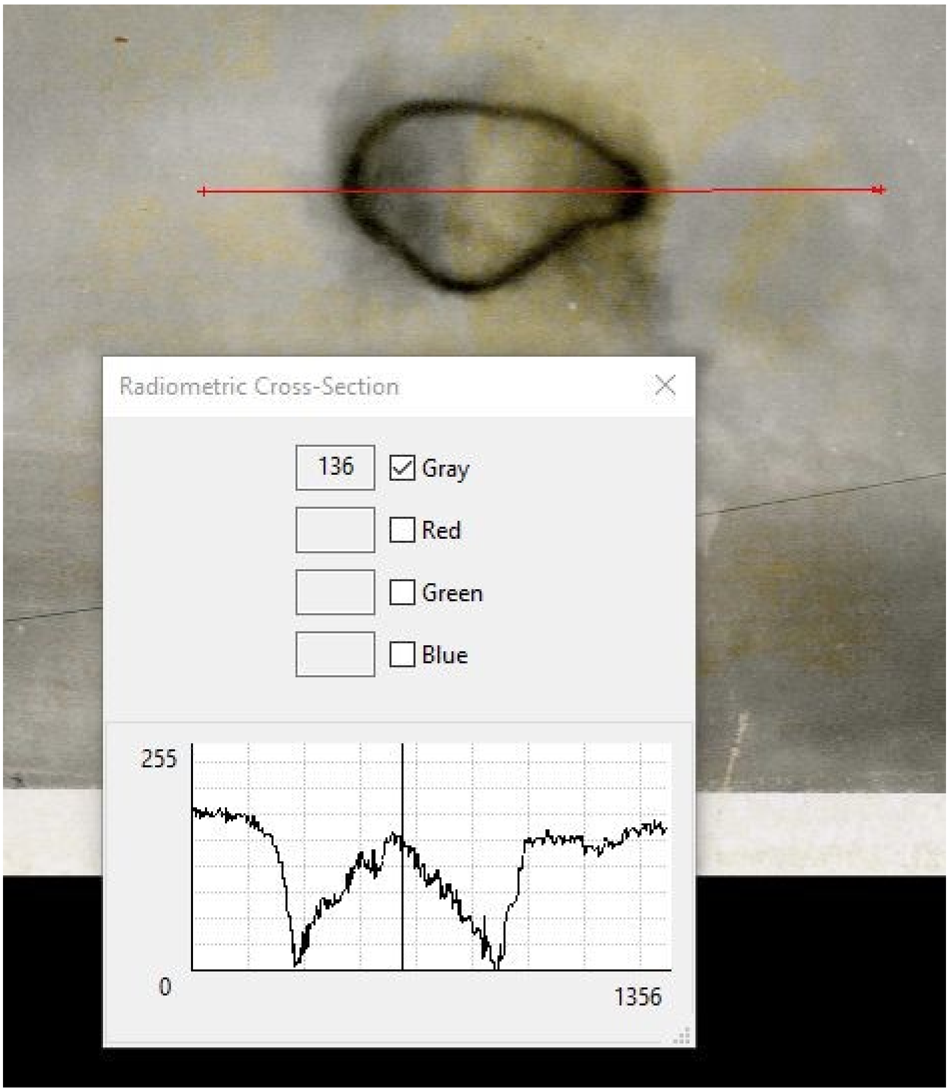
Fourth photograph

Fourth photograph **H_4** is of a very different nature from the first three and does not lend itself easily to quantitative analysis.

From a geometric standpoint, one can simply measure the angular size of the photographed shape and deduce a size-to-distance ratio from it:

The length-to-distance ratio is equal to **0.135**.

From a radiometric standpoint, one can simply display a profile along a horizontal axis:



We did not find a simple explanation for this fourth photograph, which appears to have nothing in common with the previous three, and for which the time interval separating it from the third photograph has varied according to the published reports.

We chose to stop our analysis at this point, since our conclusion regarding the first three photographs makes the case as a whole considerably less compelling.