NARCAP IR-3, 2011
International Air Safety Case Report

Photo Analysis of Color Digital Images of Anomalous Aerial Object Taken on September 17, 2010 above Santiago, Chile

Richard F. Haines

National Aviation Reporting Center on Anomalous Phenomena

January 6, 2011

Abstract

Twelve high resolution, color, digital photographs taken on Friday, September 17, 2010 in downtown Santiago, Chile were analyzed because of the presence of a small, dark, unidentified aerial phenomenon that appeared in the sky behind a formation of single engine, acrobatic propeller-driven airplanes. They were flying in level flight at 3,500 feet altitude approaching the photographer from the north. Each photo was subjected to linear and photometric measurements. It was discovered that: (1) The outline form of the UAP changed from photo to photo but remained approximately the same size, (2) In at least four of the photos the UAP had a relatively symmetrical outline that could be described either as a top or a sphere encircled by a thick ring similar to the planet Saturn. The gravitational orientation of the plane of the "ring" was always within about twenty degrees arc on either side of vertical. (3) Over a period of about eleven seconds the UAP moved across the sky toward the West (against the wind) by approximately twelve degrees and also upward by about ten degrees arc, both unknown distances; neither the distance nor size of the UAP was known. (4) Luminance stretching disclosed a light colored halo around and generally above most of the UAP images which may represent heat radiating (and rising) from the core of the UAP. It is asserted that this UAP might have been a contained plasma whose energy level was sufficient to ionize gases in the atmosphere and produce various desaturated hues along with white. It cannot be determined whether this particular UAP posed a threat to flight safety to the airplanes nearby.

Background

This research was conducted under the auspices of a joint agreement between the Comite de Estudios de Fenomenos Aereos Anomalos (CEFAA) of Chile and NARCAP to collaborate on projects of mutual concern and scientific importance. General Ricardo Bermudez, Director of CEFAA, sent an e-mail on November 15, 2010 asking if I would be interested in seeing several digital photos taken by personnel of the Chilean Air Force Public Relations Department on September 17, 2010 during the nation's bicentennial celebration of independence in Santiago. We agreed to refer to the incident as Bandera. Three (3) photos (Bandera 079, 080, and 081) were received on November 16, 2010 and a preliminary analyses on two of them (Bandera 080 and 081) was carried out. On November 18, 2010 CEFAA was sent a list of six (6) questions which further indicated my interest in seeing the entire set. I also sent CEFAA a *Memo for the Record* (see Appendix 1) briefly documenting my initial findings concerning two of these photos ((Bandera 080, 081); it was sent on November 20, 1010. On November 26, 2010 I received from CEFAA an e-mail announcing that they would be sending me the entire set of twelve digital images within separate files.[1] All jpeg files were received and acknowledged on the same day. I also asked for answers to twelve more questions related to these photos. The photographer was contacted and replied that he did not see the UAP.[2]

Weather

According to one source <www.wunderground.com/history/airport/SCEL/2010/9/19/Daily> the weather in Santiago was excellent for their air show and other festivities. Air temperature reached 77 deg F between 1400 and 1700 hrs with clear skies and reasonably high air pressure.[3] As these photos show visibility over Santiago was clear (5 miles) with only a slight haze. Winds were almost calm at 3.5 mph at noon out of the SSE. Dew point varied from 42.8 deg F at 1100 hrs, 44.6 deg F at 1200 hrs, and 41 deg F at 1300 hrs. Atmospheric sea level pressure was 30.04 inches at 1100 hrs, 30.01 inches at 1200 hrs, and 29.98 inches at 1300 hrs. In short, it was a beautiful day.

Meteorological low altitude radiosond air temperature soundings for September 17, 2010 (launched at 0800 hrs. from Santo Domingo station) are given in Appendix 2. The pressure lapse rate also appeared to be normal for this season. Satellite imagery above the southern tip of South America are presented in Appendix 3 and 4 and show a large region of clear air above the Santiago region during the period of these photographs.

Pilot Testimony

Through the courtesy of CEFAA it was learned[4] that none of the pilots saw this UAP at any time during the air show. They flew in wing-to-wing formation in straight and level flight heading

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[1] Image 079 did not contain any anomalous image

[2] Correspondence from J. Lay, CEFAA on November 27, 2010.

[3] Meteorological radiosond data received from CEFAA on December 3, 2010 indicated that on September 17, 2010 (Santo Domingo station at 0800 hrs) winds were steady at 10 mph between altitudes of 188 m to 802 m (wind direction varied between 100 deg. and 160 deg. within this same range of altitudes). Wind velocity decreased at altitudes from 1052 m to 1855 m.

[4] Personal correspondence from Gen. R. Bermudez received December 14, 2010.

toward the south at an altitude of 3,500 feet above the city. They activated their colored smoke trails before arriving at the Palacio de la Moneda. No pilot remembers noticing any magnetic compass deviation or other electromagnetic dysfunctions of their instruments during this part of their flight which might be significant.

The Photographs and Image Analyses

These photographs were taken with a Nikon D-300 digital camera by a Chilean Air Force photographer within the Public Relations Branch. The photographer was in an upstairs room (or roof top) of the Ministry of Defense Building (Edificio del Barrio Civico), Zenteno 45, Santiago. The camera was approximately at the same height as the top of the flag pole seen in each photo. Seen almost directly to the north (in each photo) was the Santiago Palacio de la Moneda beyond the flag pole and central plaza. Seen on the left side of this plaza is the Centro Cultural Palacio de La Moneda having approximately eight stories. It was learned that the lens possessed a focal length range from 18 to 22mm (F/13). Every exposure was 1/250 second long at equivalent ISO 200 exposure speed and 4288 pixels wide by 2848 pixels high with a resolution of 300 pixels per inch.[5] Appendix 6 provides the spectral response curves for this camera.

A new photograph was taken approximately every second apart; the eleven photos were taken within eleven seconds. Appendix 7 presents the estimated and actual durations. Figure 1 shows the basic, full frame scene (Bandera 080) with key locations labeled for future reference. Two locations on the center airplane were selected for luminance measurements, the landing light (Point A1) and the upper engine cowling or propeller hub (A2) that reflected an almost specular reflection of sunlight.

Point R ("right center") was the upper corner of a tall building in the distance to the west that was visible in every photograph. Point B ("bright") was on the whitest and brightest part of the sunlit flag of Chile and represented the brightest area in each photo. Point D ("dark") located below point B was the dark horizontal rectangle seen directly in front of the government building at ground level.

[5] Personal correspondence received on December 31, 2010 from Col. D. Harvey (Chilean Air Force, Public Relations Department).

Figure 1. Bandera 080 (full frame; looking north toward Santiago's Palacio de la Moneda)
(With Annotations Related to Measurements in Text)

Enlarged UAP Photos

The UAP in each photograph was enlarged by the same amount, labeled, and included here as Figures 2 through 12.[6] Figure 2a is Bandera 080, the first in the series in which the UAP was imaged. These enlargements all measured 504 pixels wide but varied slightly in height (from 534 to 580 pixels). This small variation in height does not affect the height of the UAP itself; it is portrayed by the same amount in each case.

[6] Bandera 079 was not included since it did not include any UAP image according to Air Force sources.

Figure 2a. Bandera 080
Full Color Enlargement of UAP. (Integrated Red, Green, Blue Hues)

Luminance measurements were made at several locations in the sky background as discussed below, related to Table 1. As expected the sky is almost homogeneously luminous. Within the "body" of the UAP imaged in Figure 2a, on the other hand, one can see several regions of different hues and luminance. Three of the four tips appear relatively sharp and their connecting sides are relatively straight and geometric.

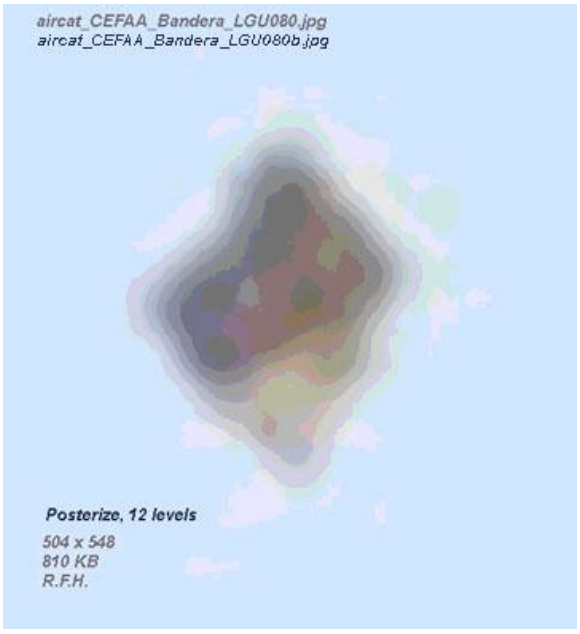

Figure 2b Bandera 080
Posterized in 12 Levels.

Relatively parallel and closely spaced common-luminance gradients in these posterized images suggest a relatively constantly changing luminance between the "body" of the UAP and the sky background. Note the large deviation of generally parallel luminance lines in the bottom third of the UAP suggesting an irregular region of equivalent luminance values, perhaps suggestive of a more amorphous, gaseous "body".

Figure 3a. Bandera 081
Full Color Enlargement of UAP. Main body has become darker and thinner than previous image within approximately two seconds.

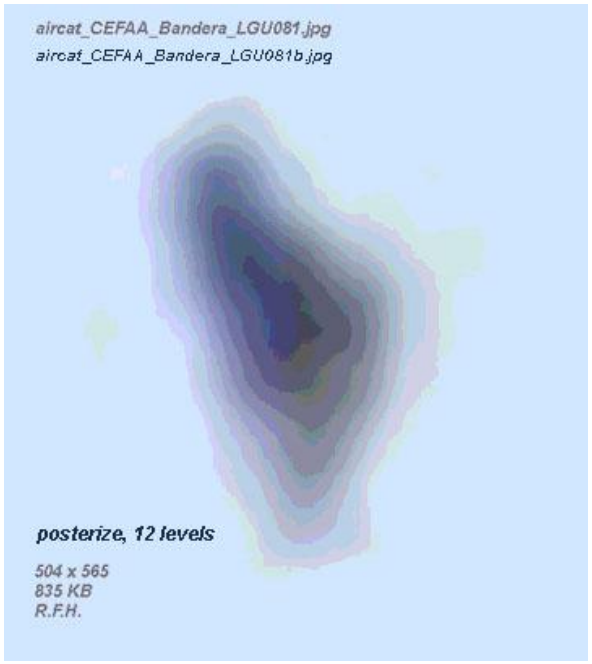

Figure 3b. Bandera 081
Posterized in 12 Levels.

Figure 4a. Bandera 082
Full Color Enlargement of UAP. Orientation of
Major Axis and Apparent Hues have Changed from Previous Image.

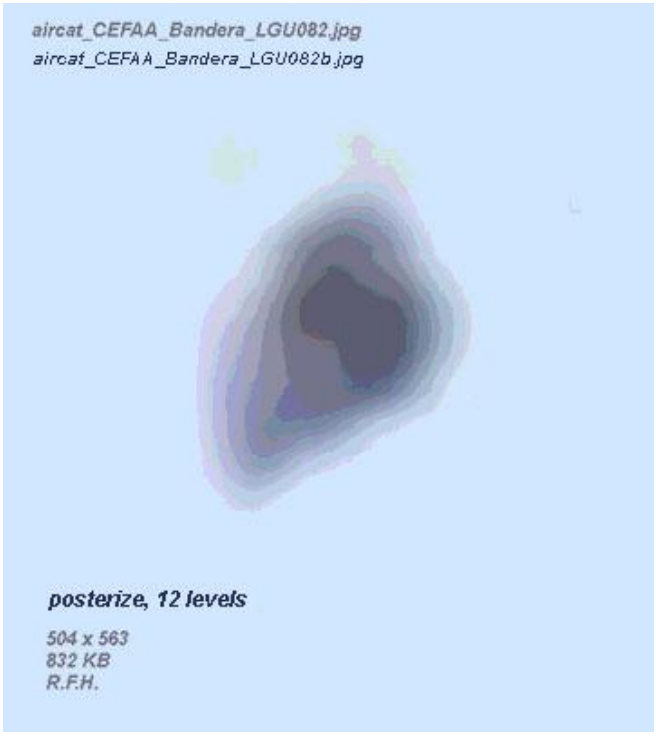

Figure 4b Bandera 082
Posterized in 12 Levels

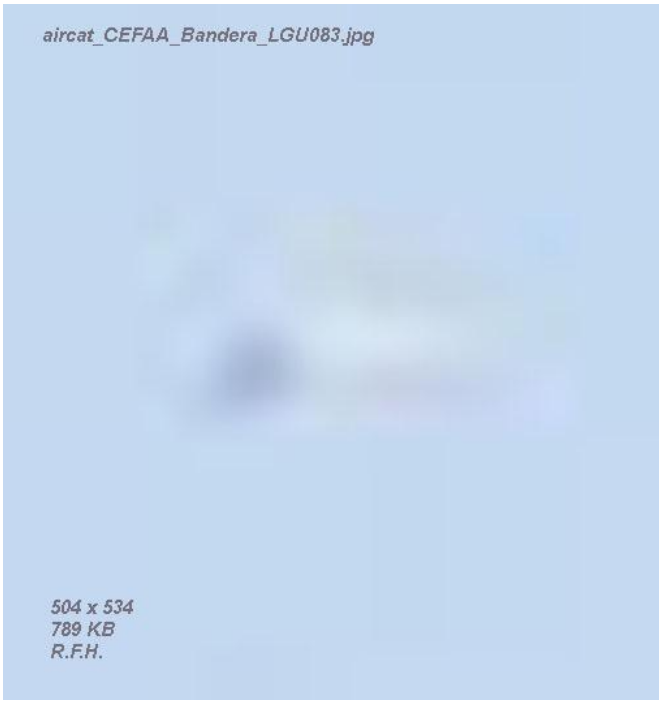

Figure 5a. Bandera 083
Full Color Enlargement of UAP. Main body has become more transparent (or lighter) and its longitudinal axis has rotated compared with the previous image

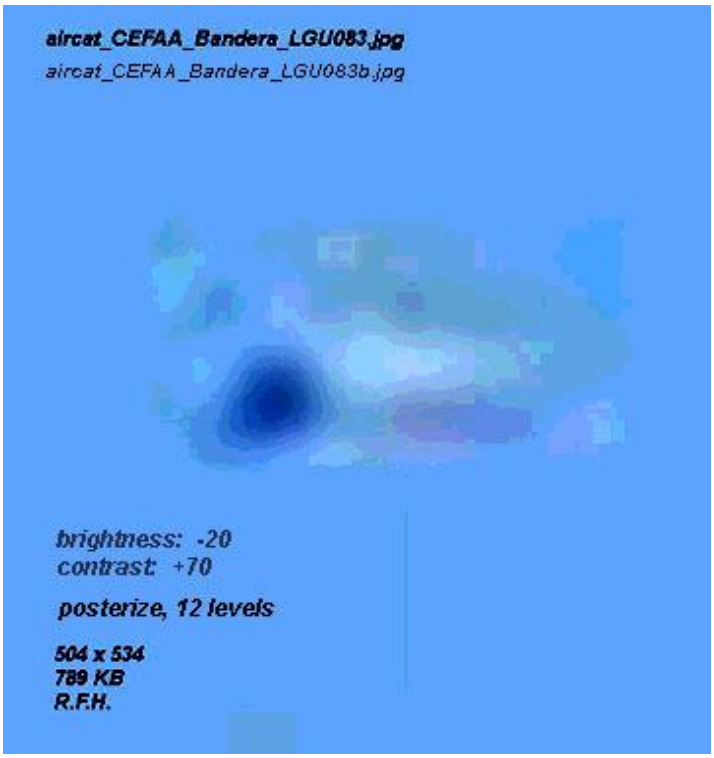

Figure 5b Bandera 083
Posterized in 12 Levels

The contrast of the UAP in Figure 5a was so low that in order to posterize it in Figure 5b both its brightness and contrast had to be changed to the values shown. Doing this darkened the background sky color. It may be noted that the UAP does not appear like the previous red, green, blue images in that the equal luminance boundaries are not all closed; the emitting regions of UAP luminance are more fragmented, again suggesting a non-solid body.

Figure 6a. Bandera 084

Full Color Enlargement of UAP taken at 0821:59 hrs. Local Time (f/22)
Main body has rotated again and earlier hues have reappeared as compared with the previous image

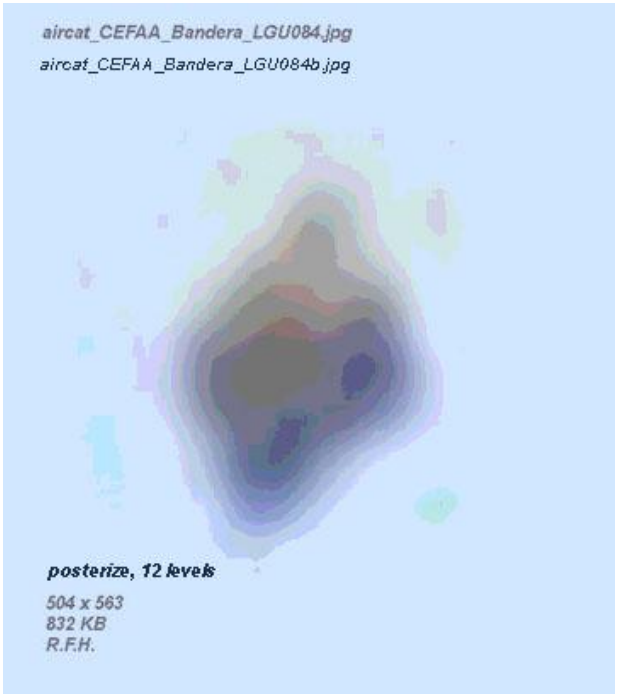

Figure 6b Bandera 084
Posterized in 12 Levels

Figure 7a. Bandera 085
Full Color Enlargement of UAP taken at 0822:00 Local Time (f/20).
Main body has shrunk in size compared with the previous image

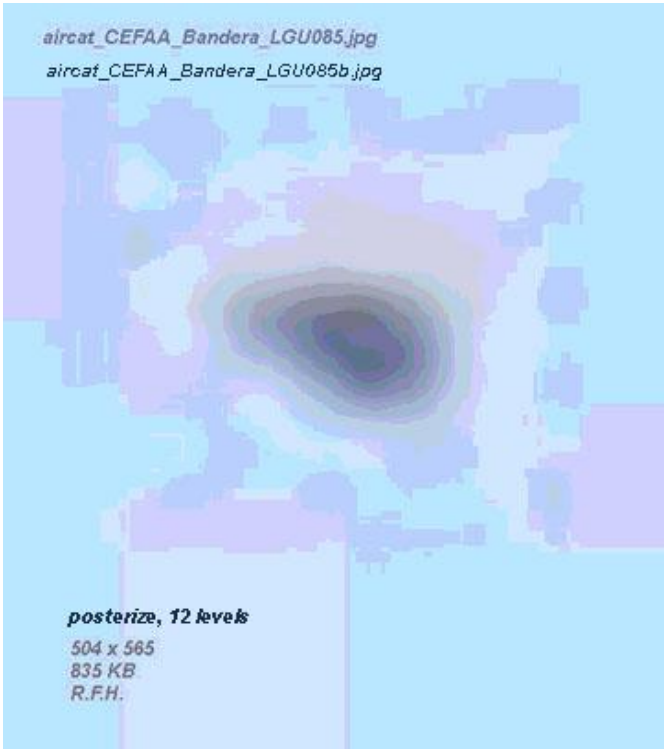

Figure 7b. Bandera 085
Posterized in 12 Levels

Figure 8a. Bandera 086
Full Color Enlargement of UAP taken at 0822:005 Local Time (f/20).
Main body has changed in shape again compared with the previous image

Figure 8b. Bandera 086
Posterized in 12 Levels

Figure 9a. Bandera 087
Enlargement of UAP taken at 0822:01 Local Time (f/18).
Compare appearance of main body with Figure 5.

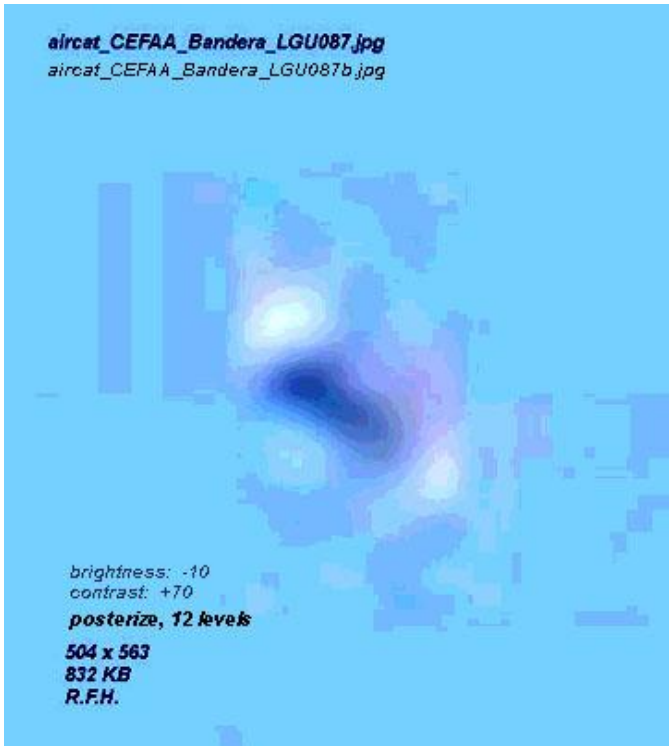

Figure 9b. Bandera 087
Posterized in 12 Levels

Figure 10a. Bandera 088
Full Color Enlargement of UAP UAP taken at 0822:02 Local Time (f/18).
Main body has changed in shape, density, and orientation compared
with the previous image

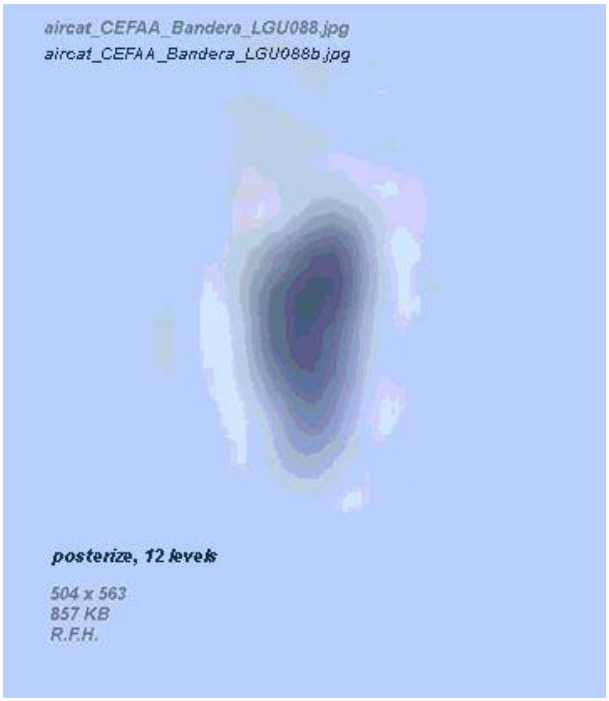

Figure 10b. Bandera 088
Posterized in 12 Levels

Figure 11a. Bandera 089

Full Color Enlargement of UAP taken at 0822:03 Local Time (f/18).
Main body has assumed a "Saturn" shape with apparent central sphere surrounded by a ring

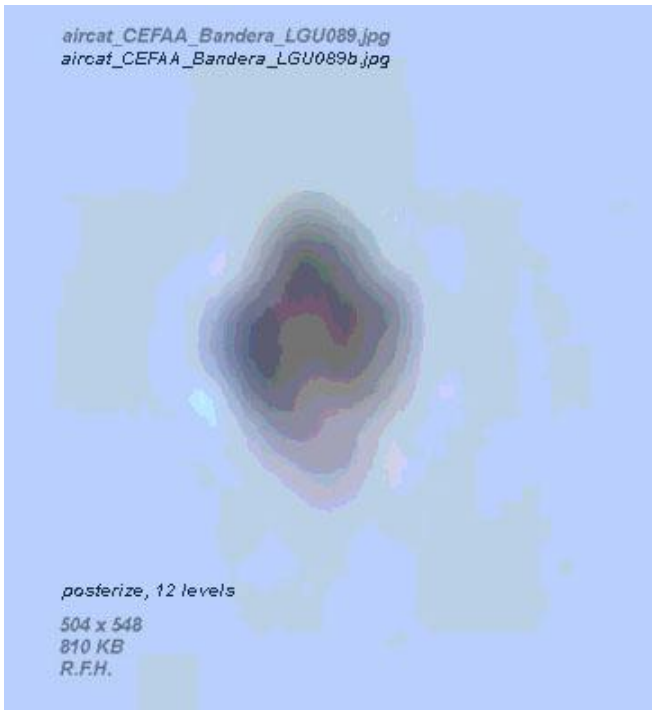

Figure 11b. Bandera 089
Posterized in 12 Levels

Figure 12a. Bandera 090

Full Color Enlargement of UAP taken at 0822:03 Local Time (f/18).
Basic shape is similar to previous image with small CCW roll.

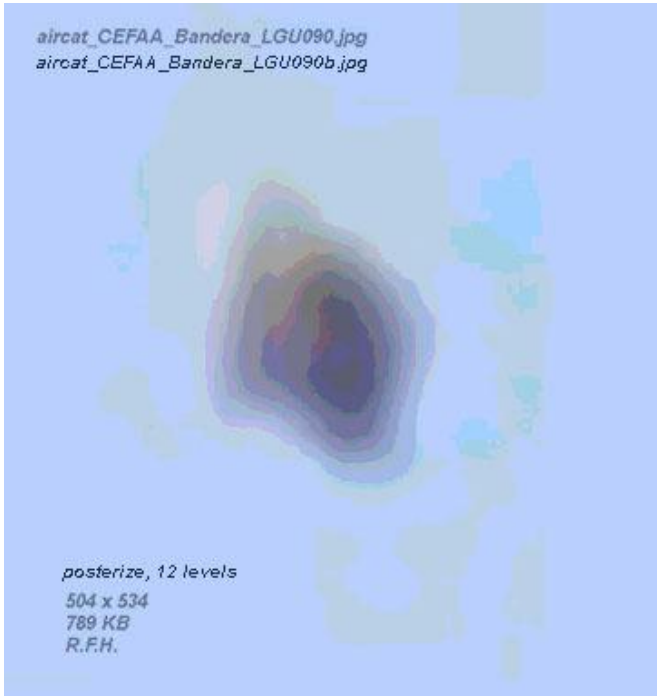

Figure 12b. Bandera 090
Posterized in 12 Levels

Linear Image Measurements

The camera was assumed to be tripod mounted. As the various focal lengths indicate for the above UAP enlargements the camera lens was zoomed during this series of photographs as is shown by comparing Figure 13 with 14. With each photograph enlarged by the same amount the horizontal pixel count was obtained for each end of the three-story (Palacio) building seen beneath the air-planes. Changes in pixel count provided an approximate measure of the degree of lens zoom over this series of photographs. The lens was slowly zoomed back during the first six photos and then was not changed for the final five.

Figure 13. (Above) Full Frame at Beginning of Series Bandera 079

Figure 14. Full Frame at End of Series Bandera 090

Does the UAP Move About in the Sky?

The simple answer is "yes." Referring to Figure 1, the top corner of a distant building (marked "R") on the right was used as a stable reference point for both horizontal and vertical measurements of the UAP to discover if it moved in the sky. Knowing that these photographs did not include any marked degree of roll (around the optical axis) it was relatively easy to plot changes in azimuth and altitude of the UAP relative to fixed point "R" on the ground for each photo. The following results in Figure 15 have taken into account the zoom lens changes that occurred between Bandera 080 and 086. An approximation of the angular width of the scene in Bandera 086 was determined by studying a vertical (down-looking) high resolution photograph of the area in downtown Santiago (www.google.earth.com) and plotting where the camera was located and its maximal angular limits. It was discovered that the camera image possessed approximately 52 degree arc width for Bandera 086. A cropped version of this same photograph was selected for use as the background of Figure 15 in order to portray the flight path of the UAP (shown by small letter 'o' representing each successive photograph) relative to the five airplanes and city buildings below.

Within a span of time of about eleven (11) seconds the UAP moved horizontally by approximately twelve arc degrees and vertically by about ten arc degrees. Linear measurements showed that the UAP moved around in the sky. Because neither the absolute size nor distance of the UAP are known it is not possible to comment on whether the object is changing in range (i.e., distance from the camera).

Figure 15
Reconstructed Flight Path of the UAP
Cropped Version of Bandera 086

It was also learned that the camera's central axis was aimed about seven (7) degrees arc west of magnetic north, again using the Google-Earth utility as the geographic reference. The angular (two-degree) tic marks shown across the top of Figure 15 are approximate and were determined by knowing the angular width of Bandera 086. It can be noted that the UAP moved upward and to the left (Westerly) although local winds at the time were from the SSE at about 3.5 mph.[7] There is no way that a free floating (passive) balloon could have moved as far as this UAP did within eleven seconds.

Selected Luminance Measurements

The relative luminance of various objects and scene locations was determined for each photograph. They included:

(1) Airplane landing light on the center airplane
(2) Sunlit engine cowling on center airplane
(3) Brightest spot on the UAP (B)
(4) Darkest spot on the UAP (D)
(5) Center of UAP
(6) Four orthogonal sky background areas around the UAP
(7) Luminance difference between measurement (3) and (4)

These findings are presented in Table 1.

Table 1
Basic Luminance Measurements
(Brighter is Higher Numbers: 0 to 255 bits)
(R = red; G = green; B = blue; LC = Left center; RC = Right center)

Photo		Landing Light	Engine Cowling	UAP			Sky				UAP
	Hue	(1)	(2)	Brightest (3)	Darkest (4)	Center (5)	LC (6)	Top (6)	RC (6)	Bottom (6)	(3) – (4) (7)
080	R	247	236	192	126	131	209	214	210	207	66
	G	240	236	178	123	122	225	228	226	224	55
	B	234	238	164	132	120	241	241	242	240	32
081	R	247	231	163	79	82	204	203	204	207	84
	G	239	240	171	84	83	221	220	221	222	87
	B	235	255	194	124	113	239	236	239	243	70
082	R	235	242	183	88	103	199	200	203	202	95
	G	236	244	184	93	100	220	218	219	220	91
	B	231	255	215	115	119	241	240	244	242	100

[7] Information provided from www.wunderground.com/history/airport/SCEL/2010/9/17/Daily

083	R	255	234	215	168	210	196	196	195	196	47
	G	245	238	229	185	223	216	216	217	216	44
	B	235	250	242	213	239	249	240	240	240	29
084	R	253	244	168	97	125	196	197	196	196	71
	G	241	245	160	106	119	218	217	218	218	54
	B	229	250	157	142	121	242	241	242	242	15
085	R	254	232	173	104	198	190	190	190	190	69
	G	234	239	175	114	118	214	214	214	214	61
	B	199	255	198	147	151	240	240	240	240	51
086	R	255	232	194	72	74	190	193	191	191	122
	G	245	232	207	77	77	214	215	215	215	130
	B	243	242	234	119	118	240	239	241	241	115
087	R	255	255	218	162	174	188	188	188	188	56
	G	238	252	226	175	185	212	212	212	212	51
	B	215	255	245	205	212	240	240	240	240	40
088	R	255	255	198	81	85	184	186	184	184	117
	G	243	255	218	89	95	209	213	209	209	129
	B	213	251	243	125	130	239	240	237	240	118
089	R	----	----	195	96	120	177	177	179	179	99
	G	----	----	207	102	114	203	203	202	203	105
	B	----	----	231	124	124	236	236	234	237	107
090	R	255	255	193	93	112	173	172	173	178	100
	G	254	254	206	91	108	202	202	202	202	115
	B	230	255	223	128	123	236	240	236	238	95

Several comments are warranted concerning the relative luminance data of Table 1. First, the luminance of the center airplane's landing light is so bright that it saturated (or almost saturated) the camera's CCD in all three wavelengths. This kind of effect has been found in previous investigations of this kind. Second, the luminance of the plane's engine cowling (or polished propeller hub) tends to be slightly brighter than the landing light. If this particular airplane surface is a specular (i.e., mirror) reflecting polished metal surface this would be expected. Third, if we can assume that higher relative luminance values represent greater optical power then, within each of the three hues measured, as the airplanes approach the camera the brightest area on the UAP tends to *increase* in luminance relative to sky luminance for some unknown reason. A decrease in range to the UAP over time would not explain this effect. Fourth, the difference between the maximum and minimum luminance of the "body" of these UAP images tends to increase over time with the largest luminance differences occurring in the blue hues. Fifth, the two UAP photographs where the "body" is almost transparent (viz., Bandera 083 and 087) raise important questions about the possibility that the UAP was modulating its energy output in a cyclic pattern that varied from:

Bandera 080 through 082 …… Dark or opaque body
Bandera 083 …… Semi-transparent body
Bandera 084 through 086 ……. Dark or opaque body
Bandera 087 …… Semi-transparent body
Bandera 088 through 090 ……. Dark or opaque body

If this is an accurate observation then further research is called for on physical mechanisms that can produce this type of periodic "transparency" or "cloaking" effect.

Luminance Range Within the Photographs

Referring to Figure 1, point "B" (the brightest part of the Chilean flag seen at the center of each photograph) was used as the maximum exposure within the scene in the absence of anything brighter. Sunlit, white, diffuse clouds would have been better. Point "D" was located near the center of the small dark, horizontal rectangle sitting on the pavement between the flag pole and the main entrance to the Palacio. It represented the minimum (darkest) exposure within the scene. The difference in luminance between these two points established the maximum dynamic luminance range for each photo as well as for each hue.[8] These measurements are given in Appendix 5 where it is seen that the photographer and camera did an outstanding job of capturing a wide dynamic range of scene luminance. Of the 255 possible bit levels of luminance the *largest* difference in scene luminance between the brightest and darkest locations was: Red = 207, Green = 201, and Blue = 202. Likewise, of the 255 possible bit levels of luminance the *smallest* difference in scene luminance between the brightest and darkest locations was: Red = 177, Green = 165, and Blue = 175.

Referring to the luminance of the sky background around each UAP image these red, green, and blue relative luminance measurements show that: (1) the sky is almost homogeneously luminous within each photograph and (2) the sky darkens as the UAP rises into the sky as is expected from the scattering of solar radiation in airborne particulate matter.

Additional UAP Measurements

Luminance Stretching Results

Most "high-end" digital cameras available today employ a very large array of microscopic size sensing elements - incorrectly called pixels[9] - upon which the image from the lens system falls. Each is a sensitive charge-coupled device (CCD) that responds to red, green, or blue wavelengths. See Appendix 6 for these spectral sensitivity curves; although a stock (off-the-shelf) model Nikon D300 is not sensitive beyond 700 nm in the infrared the camera used for the data of Appendix 6 was modified to extend its sensitivity farther into the infrared as is shown. These three wavelength-sensitive micro-size areas are placed side-by-side so that their integrated red-green-blue (RGB) output produces the

[8] Relative luminance refers to a dimensionless scale ranging from 1 to 255 (bits). Larger numbers represent brighter (more luminous) pixels. As the data of Table 1 show clearly, both the landing light on the center airplane and its engine cowling/propeller hub produced fully saturated pixels in several photographs.

[9] Pixel stands for *picture element*. The camera used in this series of photographs captured 12.2 megapixels per image.

full colored image that is seen on the camera's display and on subsequent photographic prints. Note that camera manufacturers tend to use different CCD arrays having differing wavelength sensitivities and ranges for each hue with some (usually small) degree of overlap.

Also, considering only the luminance domain, in most color cameras each sensing area (pixel) is designed to discriminate 8 bits of luminance, i.e., 256 discrete levels with 0 = black and 255 = maximum luminance. This scale is relative and usually is not calibrated against a standard.[10] Nevertheless, given the minimum and maximum pixel luminance within each photograph all the rest may be related within this range (cf. Appendix 5).

Because each full color (RGB) photograph is the end result of integrating three wavelength bands it is possible to study the relative contribution of each wavelength to the resultant full color image. Something of interest within the UAP image that is related to wavelength may be discovered by doing so. The results of this kind of analysis is presented below for several of the Bandera photographs.

Figure 16 – 18 presents Bandera080 subjected to luminance stretching. What this means is that only a small percentage of the total 255 bits of (input) luminance data are mapped into the final (output) image shown below. This procedure helps to visualize small luminance differences in the original image in each band of wavelengths making up the final RGB photograph. Figure 16 presents the red results. Figure 17 the green results and Figure 18 the blue results.

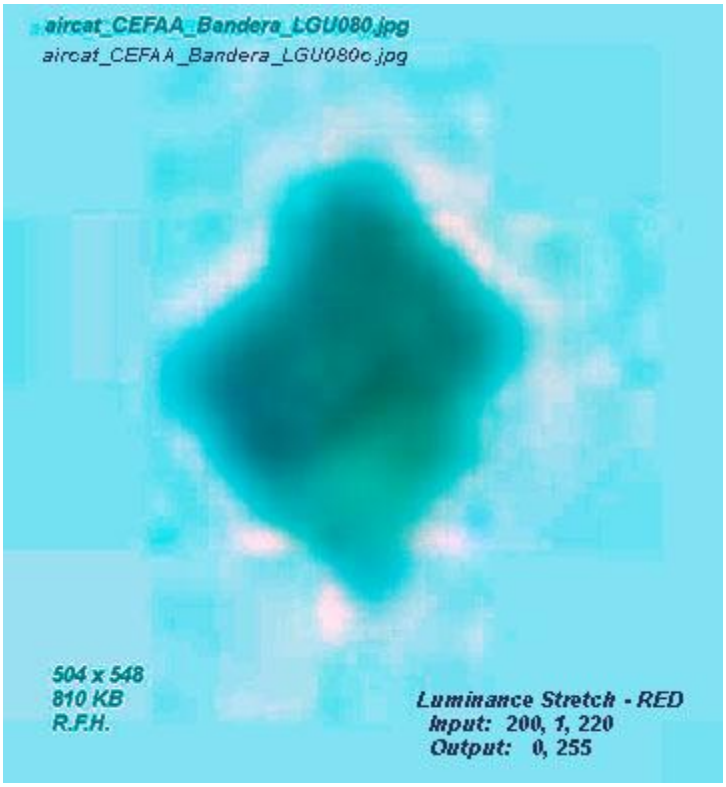

Figure 16 Bandera 080
Luminance Stretched - Red Pixels Only
(Input: 200, 1, 220; Output: 0, 255)

[10] The spectral curves of Appendix 6 were determined using a monochromator.

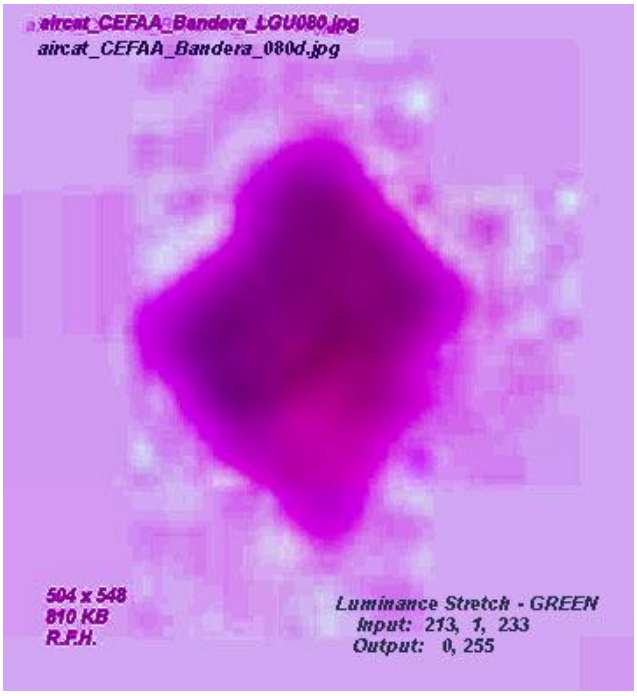

Figure 17 Bandera 080
Luminance Stretched - Green Pixels Only
(Input: 213, 1, 233; Output: 0, 255)

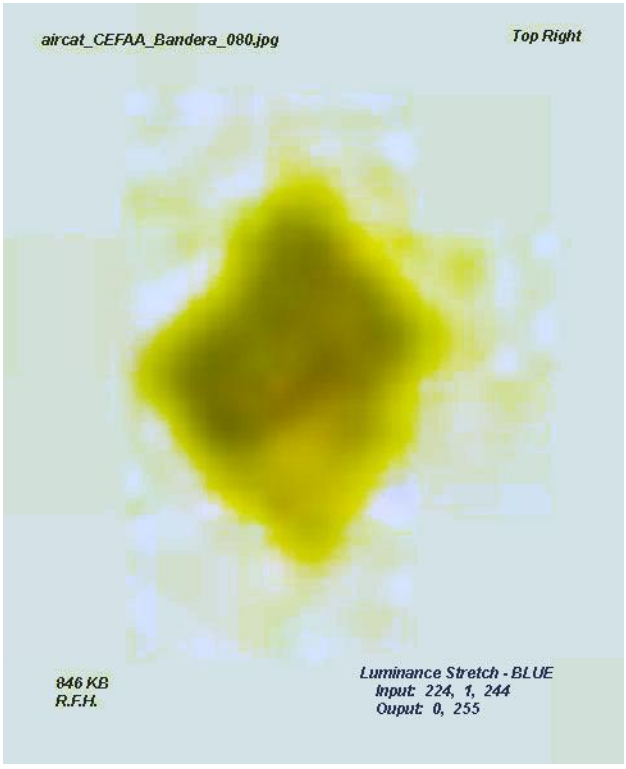

Figure 18 Bandera 080
Luminance Stretched - Blue Pixels Only
(Input: 224, 1, 244; Output: 0, 255)

There is a remarkable similarity between Bandera 080, 084, 089, and 090 when the same amount of luminance stretching is performed in each of the three hues. To illustrate these similarities compare Figure 16 (red sensitive pixels) with Figure 19 (Bandera 084; red sensitive pixels) with Figure 20 (Bandera 089, red sensitive pixels) with Figure 21 (Bandera 090, red sensitive pixels).

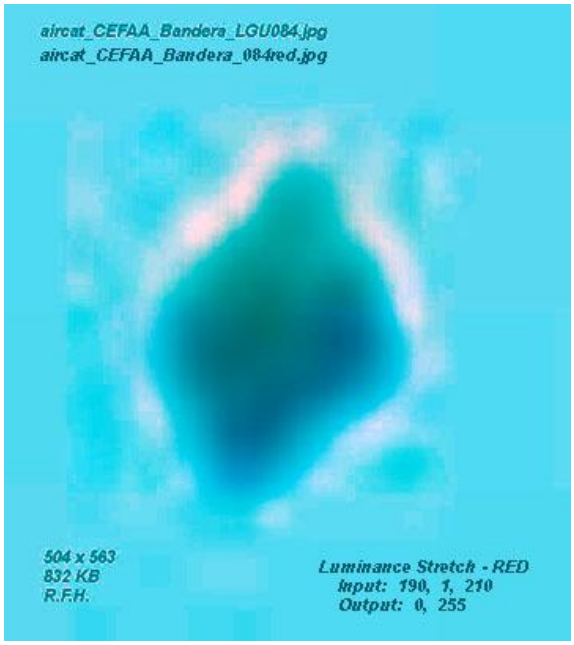

Figure 19 Bandera 084
Luminance Stretched - Red Pixels Only
(Input: 190, 1, 210; Output: 0, 255)

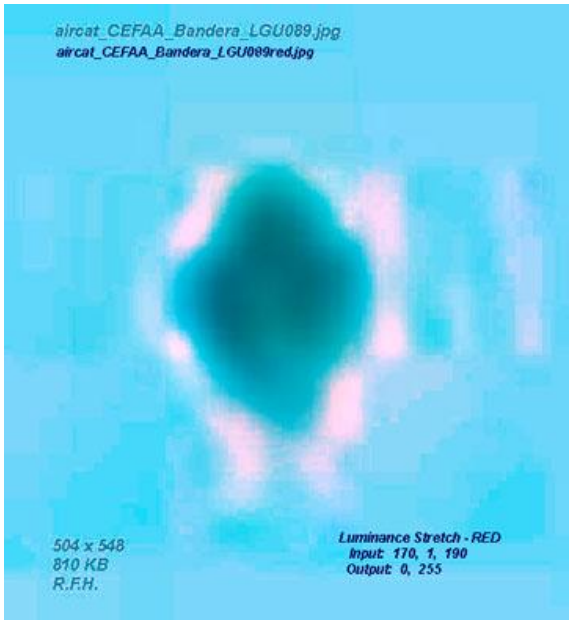

Figure 20 Bandera 089
Luminance Stretched - Red Pixels Only
(Input: 170, 1, 190; Output: 0, 255)

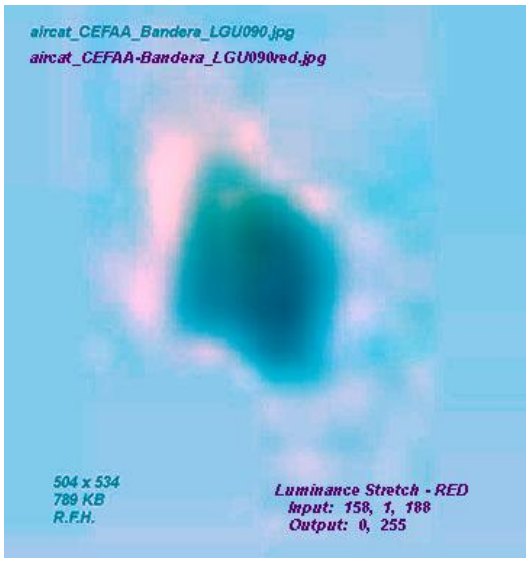

Figure 21 Bandera 090
Luminance Stretched - Red Pixels Only
(Input: 158, 1, 188; Output: 0, 255)

Figures 16, 19, 20 and 21 present a remarkably similar outline form of this UAP, viz., a relatively symmetrical, top-shape (or Saturn-shape seen from the side) with its longer axis generally oriented along the gravity gradient. A lighter halo extends a small distance away from it. Luminance stretched images in the green and blue hues for these same figures show a less pronounced halo, suggesting that the halo exists in the longer (red) (heat?) wavelengths.

Evidence of Rising Heat?

When the lighter regions surrounding the luminance stretched images are carefully examined in all eleven photographs it becomes apparent that this lighter region is found more often at the upper sides and top of the UAP and to a much lesser degree (or not at all) at the bottom of the UAP in seven of the eleven images (58%). I assert that this lighter region represents heat that is rising from the surface of the UAP. Figures 22 through 24 illustrate this effect for red sensitive pixels only.

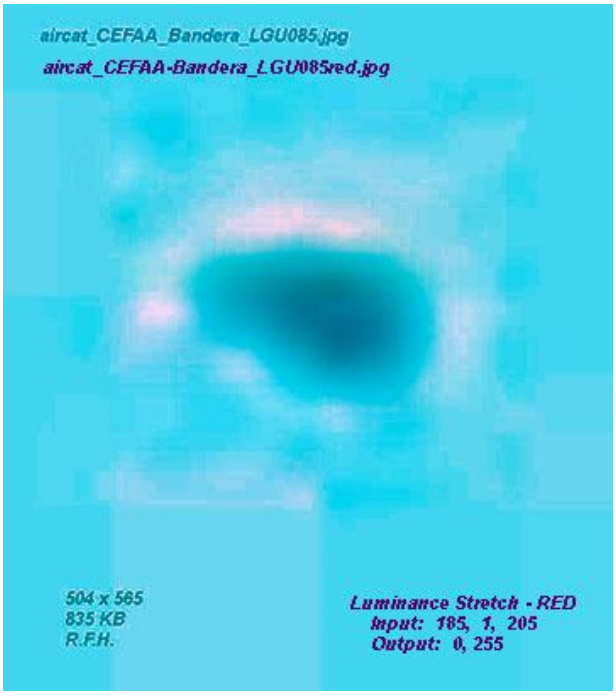

Figure 22 Bandera 085
Luminance Stretched - Red Pixels Only
(Input: 185, 1, 205; Output: 0, 255)

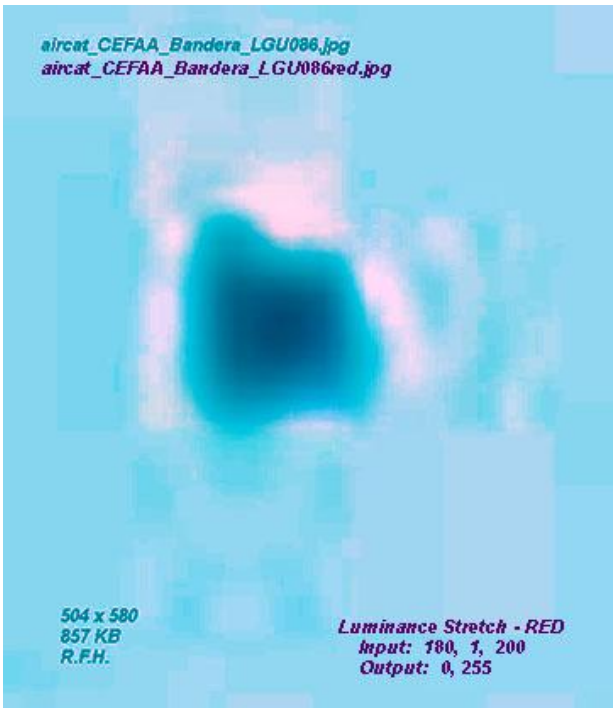

Figure 23 Bandera 086
Luminance Stretched - Red Pixels Only
(Input: 180, 1, 200; Output: 0, 255)

Figure 24 Bandera 087
Luminance Stretched - Red Pixels Only
(Input: 180, 1, 200; Output: 0, 255)

Referring to Figure 24, it is asserted that the pink regions represent heat that is being given off from the body of the UAP and is rising and dissipating with distance.

Calculated Dimensions of the UAP

Because the range to the UAP is not known all that can be done is to calculate its longest dimension at several assumed distances from the camera using a linear measurement of its width on the photograph[11] relative to the known width and distance of selected buildings and other locations that are seen at a right angle to the camera's line of sight. The results of these calculations are presented in Table 2. They should be considered very approximate and probably within an order of magnitude of being accurate.

Table 2

Theoretical UAP Dimensions

Assumed Range to UAP (feet)	(miles)	UAP Width (feet)
5,280	1.00	8.9
10,000	1.89	16.8
15,000	2.84	25.2
20,000	3.79	33.6
25,000	4.73	42.0

[11] Bandera 084 was used to obtain the linear and angular referents noted.

If these five pilots flew directly beneath this UAP it would have been illuminated by sunlight coming from their right side (from the West). Since these airplanes were flying at 3,500 feet altitude (AGL) it is most probable that the UAP was at a much higher altitude, say 20,000 feet or more and therefore would not have been easy to see from the airplanes. The fact that the pilots were concentrating on maintaining their close formation also argues against their noticing the UAP. No pilot reported seeing it.

Discussion

This discussion is confined to the speculative assertion that the UAP imaged in the Bandera series of photographs (and also many other similar photographs taken around the world) represents a plasma that is contained or confined to the approximate form seen in these photographs by a spinning magnetic field along the lines described by Rostoker, et al. (2006).

A comparison of all eleven photos enlarged by the same amount shows that the UAP remains remarkably similar in overall (maximum) dimension but changes in its form. This finding argues against it being a rigid aero-space vehicle of some kind that is merely presenting different sides to the camera in each photograph. No such aero-space vehicle is known to exist yet. In four of the eleven (36%) photos the UAP seems to assume a relatively constant form (cf. 080, 084, 089, 090). It is speculated that this relatively symmetrical "top" shape is its fundamental form because its plasma is spinning about an axis that is seen from the side, the bulge on each side possibly representing a toroidal (magnetic field) ring. The UAP also appears to change into less symmetrical tear-shaped forms from time to time. Why it might return to this symmetrical "top" shaped form might be related to magnetohydrodynamic[12] processes trapping the atoms that have gained or lost electrons within a spinning plasma volume. If this UAP was spinning either within an adjacent atmospheric vortex or spinning independently of local air molecules an associated magnetic field could contain the electrons.

Given that a contained plasma is similar in some characteristics to ball lightning (BL) investigators today are not in agreement whether there is a single (still unknown) phenomenon causing (BL) and related luminosities or multiple phenomena each possessing its own mechanism. Barry (1980) and Turner (1998) give some evidence for two separate types yet concluded that only one fundamental phenomenon was involved.

The general appearance of this series of Bandera images is that of a generally achromatic, amorphous, constantly changing *bounded form*[13] with generally rounded corners, reflecting or emitting luminous radiation in a limited number of wavelengths (within the visible spectrum). It is asserted here that this UAP was a luminous *contained plasma*.[14]

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[12] Plasma dynamics interacting with self-generated and/or externally applied magnetic fields is known as the academic discipline of magnetohydrodynamics.

[13] The term *bounded form* refers to a three dimensional volume possessing a single, continuous surface. The nature of this surface and its core makeup remain to be identified.

[14] A plasma is a state of matter (like a gas) within which some of the particles are ionized (loss of electrons). This process is thought to involve a dissociation of molecular bonds that reduces it into its constituent atoms. In general, plasmas respond to magnetic fields and possess high electrical conductivity. It is because plasma is quasi-neutral (positive and negative charge concentrations are homogeneous) that is free of large electric

At this point one can only speculate on the source and kind of energy that is inside the UAP in order to make it radiate as a luminous plasma. While it might be electrical,[15] chemical, thermal (or something else in nature) its originating source is not yet known. It is known, however, that the separation distance of charged particles within a plasma has to be small enough to allow each particle to influence many nearby charged particles. Thus, a plasma (by definition) exists when the number of charge carriers (within a volume called the *Debye sphere*) of a particular type of particle is greater than unity; at this point the medium will behave collectively. When electron plasma frequency of the oscillating electrons is large as compared to the frequency of the electron-neutral collision frequency electrostatic interactions will tend to dominate over the more usual gas kinetic processes. It is also known that plasmas can exist over a very wide range of parameters such as size, particle density, temperature, lifetime, and magnetic field strength. Perhaps these facts help explain why plasma is so ubiquitous in the Universe.

Similar shaped self-luminous UAP have been reported and photographed and studied before (Haines, 2010).

UAP Hues

The hue that best describes Bandera 081, 082, 085, 086, 088 and 089 is a dull, medium (relatively achromatic) and relatively homogeneous gray. Bandera 080, 084, and 090 appear to possess localized regions of a light brown or tan hue along with a region of purplish gray. Bandera 083 and 087 appear almost transparent with very light gray and white areas. The histogram of wavelengths as a function of pixel count for Bandera 087[16] (almost transparent UAP) show a number of individual spectral "lines" in the red and blue bands (each with a high pixel count). The other photographs do not evidence these lines at all.

None of these photographs possessed highly saturated[17] hues as discussed above, i.e., all are dull and rather "muddy" hues. This hue desaturation effect cannot be the caused merely by the local atmosphere; the air above Santiago was relative clean at the time.

Ionization of Gasses in the Air[18]

Visible radiation is produced by atoms colliding with other atoms or by absorbing electromagnetic radiation in such amounts or rates that one or more electrons are elevated out of their normal energy states (or removed completely). As these electrons fall back into these orbital vacancies energy is released in the form of photons. These luminous particles or "photons" possess specific energy associated with specific wavelengths (hues). More loosely bound atoms radiate in the ultraviolet, visible, and infrared regions of the electromagnetic spectrum.[19] A single wavelength

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fields. It is thought that plasma is the most common phase of matter in both volume and mass in the entire Universe.

[15] For theories focused on electromagnetic radiation such as radio frequency wave mechanisms see (Kapitsa, 1955; Ohtsuki and Ofuruton, 1991).

[16] Adobe Photoshop, LEVELS function.

[17] A fully saturated hue would be produced by a single wavelength otherwise called a pure color. Pastel hues are also referred to as desaturated hues.

[18] Part of this discussion originated from detailed discussions with Jim McCampbell in the early 1970s (see McCampbell, 1973).

[19] These are thought to be responsible for the chemical behavior of atoms.

will be visually perceived and photographed as a fully saturated, pure hue. If many different visible wavelengths are emitted at the same time from a source they produce either white light or highly desaturated hues. And so the color(s) of a UAP may help us understand the amount of energy that it is radiated to the air around it.

The various atoms that comprise Earth's atmosphere are well known along with many of their attributes. While the density of each gaseous species making up air varies as a function of altitude (Anon, 1976) we shall assume the present UAP was under 5 km altitude (referred to here as dry, sea level air). One of the attributes that is of interest here is the ionizing potential (IP) of each atmospheric gaseous species, i.e., how much energy is required to produce ionization of each of these atoms? The lowest amount of energy (measured in electron volts; eV[20]) needed to lift an electron from its ground state to the adjacent higher state is called its ionization potential. Xenon is found in the air and, as indicated in Table 3, has the lowest IP of only 12.13 eV and can produce as many as 51 separate, visible spectral lines. But xenon comprises only a very small proportion of all the gases making up Earth's atmosphere. Table 3 lists nine of the primary atmospheric gases in descending order of their density in dry, sea level air along with their IP.[21] Column A represents the neutral atom state, B the singly ionized state, i.e., the amount of energy required to remove an electron from the atom absolutely, C is the doubly ionized state i.e., where a second electron is removed, etc. Fortunately the atmosphere does not contain sufficient eV energy to stimulate any of the known atmospheric gases otherwise the air would glow all the time with one or more hue(s).

Table 3

Nine Atmospheric Constituents and Their Ionization Potentials

Gas	Approx. no. visible spectral lines	Ionization Potential (eV) A	B	C	D
Nitrogen	79	14.53	29.59	47.43	77.45
Oxygen	79	13.61	35.11	54.89	77.39
Argon	219	15.76	27.62	40.9	59.79
Carbon Diox.	7	-----	-----	-----	-----
Neon	153	21.56	41.07	63.5	97.02
Helium	9	54.48	54.56	----	----
Krypton	58	14.00	24.56	36.9	43.5
Xenon	51	12.13	21.2	31.2	42

[20] One eV equals 23,053 calories per mol.

[21] It is well known that the air also contains many other molecules taking the form of dust, moisture, acids, pollutants, and others, some of which may ionize under certain circumstances.

Hydrogen	5	13.6	-----	-----	-----

Note that while nitrogen comprises the largest percentage of Earth's atmosphere (approx. 78% by weight) it has the fifth lowest IP of 14.53 eV. It produces about 79 different visible spectral lines. With the possibility of so many elements within Earth's atmosphere producing so many different spectral lines when they become ionized it would be surprising if the IP energy would be so stable and precise as to produce only single spectral lines (i.e., pure hues) in this UAP. Indeed, photographs of UAP taken over the decades have shown a wide range of readily discriminable hues (Hall, 2000).

The hues photographed in the Bandera series range from achromatic medium and light grays to purplish gray to slightly reddish brown to medium tan to white. Without a precision spectrometer it is impossible to associate these UAP hues with specific wavelengths except to assert that because none of them are highly saturated they must be produced by a mixture of different emitted wavelengths.

Conclusions

The UAP imaged in all eleven color photographs studied here is a relatively achromatic, gray, bounded form that changes its form and moves against the wind by some unknown means. It is not possible to assign a specific hue or set of hues to these UAP images but it is possible to assign a basic form to five of the eleven, viz., a vertically oriented spindle or Saturn-shape. Its calculated width could range from 10 to 30 feet or more. It is not possible to assess whether this UAP would pose a threat to flight safety because of its many unknown physical characteristics. Further research is needed to clarify whether a (postulated) plasma such as this could affect aircraft in any way.

References

Anon., U. S. Standard Atmosphere, 1976. National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, U. S. Air Force, Washington, D.C., October 1976.

Barry, J.D., Ball Lightning and Bead Lightning. Plenum Press, New York, 1980.

Haines, R.F. (Ed.), Spherical UAP and Aviation Safety: A Critical Review. NARCAP Technical Report, Paper 3.3.2, April 2010. <www.narcap.org>

Hall, R.H., The UFO Evidence, Vol. II: A Thirty Year Report. The Scarecrow Press, Inc., Lanham, Maryland, 2000.

Kapitza, P.L., O prioda sharovoi molnii (On the nature of ball lightning). Dokl. Akad. Nauk, SSSR, 101, 245, 1955.

McCampbell, J.M., Ufology: New Insights from Science and Common Sense. Jaymac Co., Belmont, CA, 1973.

Ohtsuki, Y.H. and H. Ofuruton, Plasma fireballs formed by microwave interference in air. Nature, 350, 139, 141, 1991.

Rostoker, N., M. Binderbaur, A. Qerushi, and H. Tahsiri, Magnetic and electrostatic confinement of plasma with tuning of electrostatic field, U. S. Patent 7119491, October 10, 2006.

Turner, D.J., Ball lightning and other meteorological phenomena. Physics Reports, 293, 1, 60, 1998.

Appendix 1

November 20, 2010
Memo for the Record
Subject: Comments on color digital photos labeled BANDERA received from CEFAA
By: R. F. Haines

I received three (3) high resolution, color, digital images from CEFAA on November 16, 2010 each showing the same general scene in a downtown central square area. These vertical format images showed five (5) single engine light airplanes approaching with colored smoke trails. Each image possessed a file size of about 4.663 MB at 39.5" x 59.5" (approx. 2,848 x 4,288 pixels resolution). They were labeled Bandera 079.jpg, Bandera 080.jpg, and Bandera 081.jpg.

The following steps were used on the last two images:

1) Enlarged to 100" w 150" h) An area surrounding only the UAP image measuring 1.35" x x 1.12" (97 pix x 81 pix) was cut out.
3) Above cut out was pasted into new file (aircat_FM_CEFAA_Bandera080_lg.jpg) and labeled.
4) Above new file image further enlarged to 5" x 4.25".
5) Relative luminance measured within 3 x 3 pixel groups in red, green, blue in various regions:
    1) Landing light of central airplane
    2) Upper surface of cowling on central airplane apparently reflecting full sunlight.
    3) Ten locations on surface of UAP

Bandera 080

1) The aircraft's landing light comprised an area of approx. 4 pixels wide by 4 pixels high. The red, green, and blue relative luminance values of the vertical row of pixels through the landing light were:

	R	G	B
top	223	210	202
row 2	247	240	234
row 3	255	249	243
bottom	223	218	214

2) The relative luminance of the airplane's engine cowling was scanned in three locations: i) top left side, ii) top center, and iii) top right side. The following values were obtained:

	R	G	B
top left	223	230	240
top center	236	236	238
top right	219	227	237

3) "The relative luminance of the brightest part of the UAP in Bandera 080 was found to be its lower right-hand quadrant. R, G, B values were approx. 178, 162, 147, and 191, 193, 205 for the extreme bottom tip of the UAP. It may be noted that the airplane's landing light was brighter than both of these two areas on the UAP.

The overall shape of the UAP in Bandera 080 was generally a diamond with relative height of 70 units and width of 50 units. While colors cannot be determined with precision the central and upper left region of the diamond was a darker purple while the lower 1/3rd of the diamond's point was a tan hue. The lower tip of the diamond appeared to come to relatively sharp point as did the far left corner of the diamond. The upper and right tips of the diamond were less sharply in focus (blurred?) This image could have been produced by a balloon of some kind having different colored side panels. The darker top surface and lighter bottom surface areas is very interesting and raises the possibility of ground-reflected sunshine onto bottom of UAP.

Even though these were JPEG compressed images there was no evidence found for any particular pixel distortion surrounding either the airplanes or the UAP in the blue sky background.

My general impression of the UAP shown in image 081 was that of a large dark bird in flight. If these three images were taken over a brief period of seconds then the three (3) UAP images will provide photo analysts with much useful differential information between them.

Richard F. Haines

Note: Relative luminance refers to a dimensionless scale from 1 to 255 (bits) where larger numbers represent brighter (luminance) pixels. The mean luminance of three by three pixel groups are used in order to average out minor differences of luminance within the set.

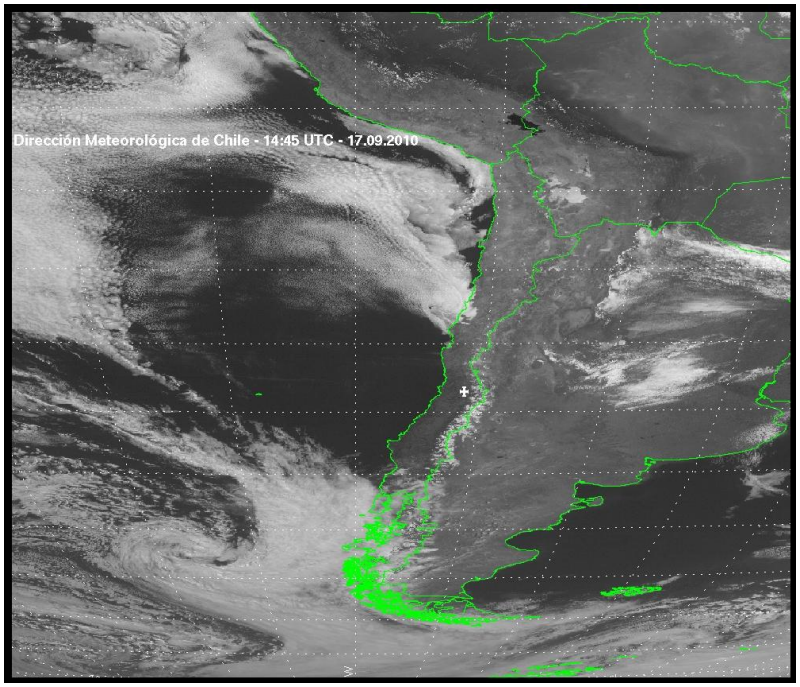
Appendix 2

Atmospheric Sounding Results for September 17, 2010
Launched at 0800 hrs from Santo Domingo, Chile
(Santo Domingo station: 0800 hrs, September 17, 2010)

Altitude (meters)	Temperature (deg. C)	Wind Direction	Wind Speed (mph)
75	7	180	04
146	9	135	09
188	11.2	120	10
230	11.3	105	10
281	11.4	103	10
340	13.8	101	10
366	14.1	100	10
427	14.8	110	10
757	14.1	165	10
802	14.0	160	10
1052	13.8	100	08
1232	14.8	057	06
1514	13.8	350	03
1775	12.8	358	01
1855	12.2	Calm	
3036	4.2	280	11
3118	3.6	270	13
3187	3.2	260	14

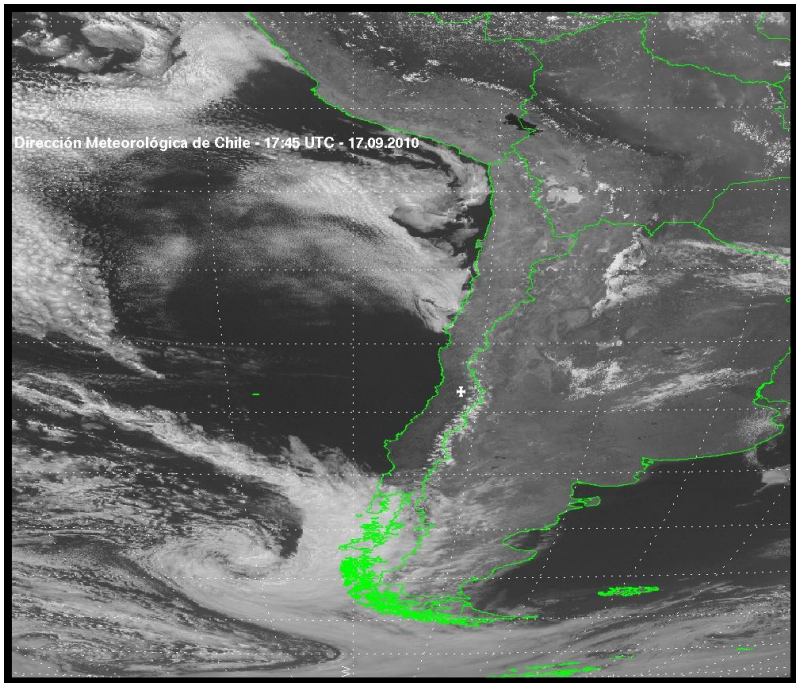
Appendix 3

Satellite Image of Chile for September 17, 2010
at 1445 UTC (1045 hrs. local time)



Appendix 4

Satellite Image of Chile for September 17, 2010
at 1745 UTC (1345 hrs local time)



Appendix 5

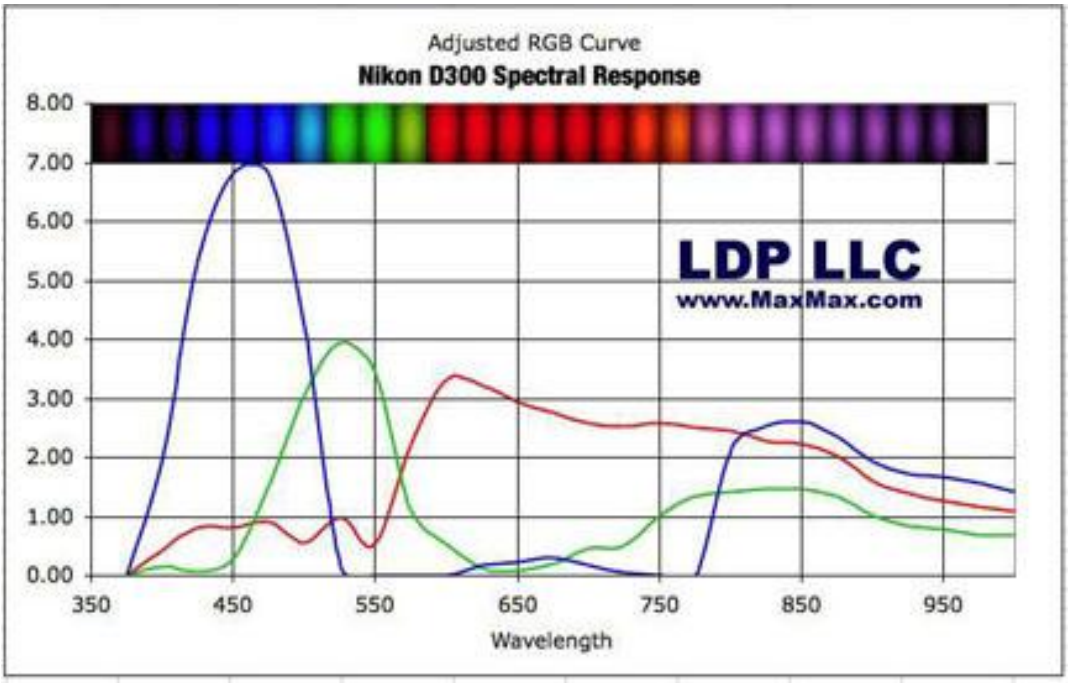
Scene Luminance Differences
(See text for explanation)

Photo No.	Hue	Difference
079	R	188
	G	178
	B	181
080	R	182
	G	170
	B	175
081	R	185
	G	174
	B	181
082	R	185
	G	178
	B	187
083	R	182
	G	174
	B	180
084	R	186
	G	174
	B	184
085	R	179
	G	166
	B	178
086	R	177
	G	169
	B	183
087	R	189
	G	181
	B	185
088	R	178
	G	165
	B	182

089	R	185
	G	179
	B	191
090	R	207
	G	201
	B	202

Appendix 6

Nikon D300 Spectral Response Curves
(From: www.maxmax.com/Nikon_d300_study.htm)



Appendix 7

Approximate Estimated Duration Between Photographs and Total Elapsed Time

Bandura Photo	Est. Duration (sec.)	Elapsed Time (sec.)
079	?	?
080	2	2
081	2	4
083	2	6
084	1	7
085	0.5	7.5
086	0.5	8.0
087	1	9
088	1	10
089	0.5	10.5
090	0.5	11