Report on Aerial Phenomena Observed near the Channel Islands, UK, April 23 2007

Jean-Francois Baure, David Clarke, Paul Fuller & Martin Shough

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Summary of the report

We describe simultaneous observations of UAPs[1] in daylight by multiple observers (aircrew and passengers) on board two civil aircraft in widely separated locations. Recordings of ATC radar data, and of radio communications reporting events in real time to Air Traffic Control, are examined alongside CAA documents, witness interviews, and other sources. A detailed reconstruction of the sighting geometry is offered. We describe attempts to explain the phenomena with the help of expert advisers and professional resources in the fields of meteorology, atmospheric optics, geophysics and other fields.

It proved possible to eliminate a number of theories with a fairly high level of confidence, but we were unable to conclusively identify the UAPs observed. We found that two theories had some potential to explain at least a majority of the features observed and might be the basis of a future explanation. But we are sensible that a potential to explain is not an explanation.

These two theories involved atmospheric-optical phenomena (specular sun reflections on a haze layer capping a local temperature inversion) or geophysical phenomena (related to 'earthquake lights' or EQL). But each theory has some interesting problems. As we state in our Conclusions (*Section 7*): 'It may prove possible for other investigators to adapt these theories and so improve the fit with observation, or further work might thoroughly rule out one or both of them.' A third candidate - a mock-mirage due a severe temperature inversion near the Breton coast - was kept out of contention by one apparently insurmountable problem.

We were able to show that widespread media stories describing enormous phenomena up to a mile wide and detected by radar were based on speculation and misunderstandings. Many news reports were grossly exaggerated and inaccurate. However as we further state:

'We are unable to explain the UAP sightings satisfactorily without either *a*) discounting at least some significant features of the reports, or *b*) doing violence to at least some conventional meteorological optics or conventional EQL phenomenology. We hope that readers of this report will find it helpful in deciding which (if either) of those courses of action seems the more reasonable and economical.'

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[1] UAP = Unidentified Aerial Phenomenon

Acknowledgements

This investigation touches on many different areas of expertise and we are grateful for the patience of many people and organisations who have assisted us with information and advice. They are credited in the text along with many print and web resources. We apologise to anyone whose name has been inadvertently omitted, and for any mistaken or absent credits which we will be glad to correct (please contact the authors*). Although we have endeavoured to check with authoritative sources wherever practical, the authors are of course wholly responsible for any errors of fact or interpretation that remain.

We would especially like to thank Capt Ray Bowyer (Aurigny Airlines); Kate and John Russell; Capt Patrick Patterson (Blue Island Airways); Jersey Air Traffic Control, Channel Islands Zone, in particular Paul Kelly (Air Traffic Controller), Simon Langlois (engineer, ATC Radar Processing) and Jeremy Snowdon (Director of Civil Aviation, formerly Chief Electronics Engineer); Anthony Pallot (Principal Meteorological Officer, Jersey Meteorological Dept); Frank LeBlancq (Jersey Meteorological Dept); Tim Lillington (former Senior Meteorological Officer, Guernsey Airport Met Office); Les Cowley (physicist, atmospheric optics; author of CHANNEL ISLANDS SIGHTINGS: *An Investigation into Possible Role of Atmospheric Optical Phenomena, 2007*, a report kindly prepared for us by Dr Cowley at an early stage in our investigation which helped greatly to focus the direction of our efforts); Andrew T Young (atmospheric scientist and expert on optical mirage, San Diego State U.); Friedemann Freund (NASA, geophysics of earthquake precursors); John S. Derr (US Geological Survey, earthquake lights researcher); Miguel Angel Rico-Ramirez (radar meteorologist, Bristol U.); Robin Hogan (cloud physicist, Reading U.); Thierry Jimonet (meteorologist, METEO-France, Toulouse); Bertrand Chapron and Francis Gohin (oceanographers, *Institut français de recherche pour l'exploitation de la mer*, IFREMER, Brest); Pierre Blouch (Meteo-France E-SURFMAR Programme Manager, Centre de Meteorologie Marine de Brest); Loic Harang (CENTRE DE METEOROLOGIE SPATIALE, Lannion); Lucien Wald (Head of Helioclim/SODA, Centre Energetique et Procedes Ecole des Mines de Paris /Armines/CNRS);Bruno Lassus (Le Commandant de Port, St.Malo Port Authority); Dundee University Satellite Receiving Station; AJB Pattimore (Deputy Harbourmaster, Guernsey Harbour Authority); Jersey Planning and Environment Department (PED, Fisheries & Marine Resources); Paul Ingrouille (Guernsey Clematis Nursery Ltd); UK Ministry of Defence; UK Meteorological Office; Aurigny Airlines; Blue Island Airways; Gary Anthony; Joe McGonagle; Jean-Pierre Pharabod; Dominic Weinstein & Kim Efishoff (NARCAP); Sara Doherty (CAA Safety Data Office).

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1) Summary of Observations

a) Aurigny Airlines 544 (BN2a Trislander)

Pilot observation

The first observation of a bright light was made by the pilot of a BN2a Mk3 Trislander (Aurigny Airline 544, G-XTOR) inbound to Alderney from Southampton on a heading of 207° on airway R41, at a position some 13nmi NNE of the ORTAC reporting point. ORTAC (approx. N 50°W 02°) marks the boundary on air route R41 between the London Flight Information Region (FIR) and the Brest FIR. It is also the N boundary of the Channel Islands Control Zone served by Jersey radar.

Capt. Raymond Anthony Bowyer began flying in 1984 and at the time of the sighting had been a professional airline pilot for 18 years, piloting numerous aircraft types (PA 34 Navajo, Fokker 27, Trislander and others) on routes in the Channel Islands, UK and Europe for companies including Novair, Regionair, Channel Express, Jersey European and Farnair Europe. He had flown this particular aircraft, Trislander G-XTOR, on this Southampton-Alderney route for 8½ years, amounting to between 500 and 600 round trips.[2]

The aircraft was in cruise at 130 knots (IAS) at somewhat over 4000 ft.[3] It was a largely cloudy afternoon (see *Section 5*) with direct sunlight blocked by medium level altocumulus and high level cirrus (sun ~ 45 deg elevation in the SW, ~17° to the right of the flight path). The E and W horizons were cloud-obscured, and there was a layer of thin haze below the aircraft at approximately 2000ft. But the horizon ahead was free of cloud, and visibility was estimated 100 miles at the flight altitude. The islands of Alderney and Guernsey were also clearly visible.

Fig.1 Location of the Channel Islands, showing the Trislander's route from Southampton to Alderney

[2] Interview by Paul Fuller, Southampton Airport, 8 June 2007, text reviewed by Capt. Bowyer and corrected and updated 16 July 2007 (see *Appendix B*)

[3] The cruise altitude was FL40, or a standard pressure altitude of 4000ft. True altitude ASL differs from this depending on local air pressure, as explained in *Section* 3.

The time was about 1406Z[4] when Capt. Bowyer noticed a bright light close to the horizon almost directly ahead of the aircraft. His initial impression was that he could be seeing sunlight reflected from large vinery glasshouses on the Island of Guernsey tens of miles away. He had often seen such an effect before, which would vanish in moments as the aircraft moved through the critical angle for reflection. But this light did not disappear, and looking closer he realised that it was something unusual apparently in the sky at or near to his own altitude (we will refer to this object as UAP #1).

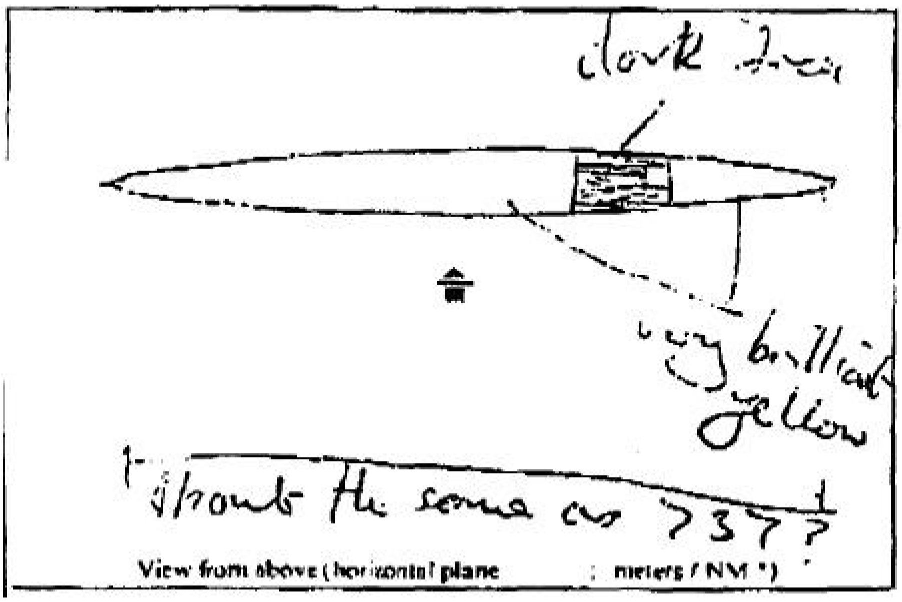

Fig 2. Capt. Bowyer' s original drawing for the CAA Air Safety Report, 23 April 2007 (see Appendix A)

The flight controls were set to 'autopilot', leaving Capt Bowyer free to observe the UAP with the naked eye and with 10x magnification binoculars. He observed what appeared to be a "sparkling yellow" object (also described as "bright orange-yellow", "golden yellow" and "sunlight yellow") whose profile was like that of a thin cigar suspended horizontally above the horizon. It appeared to be self-luminous rather than reflective and was "brilliant" but not dazzling or tiring to the eye. It had "very sharply defined" edges and pointed ends. Approximately 2/3 of the way from the left hand end, like a narrow band around a cigar (about $1/10^{th}$ of the length of the object), was a "dark graphite grey" patch. The edges of the band where it met the bright yellow were not sharp but "hazy" and the dark colour had a "shaky" or "glittering" quality that he found hard to describe, but which he felt was an objective property of the object and not an optical illusion (*Figs. 2 & 3*)

The naked eye angular subtense of UAP #1 when first seen was estimated later as equivalent to 6-7mm at arm's length, or approximately 0.5° of arc. His initial impression was that it was a 737-sized object, or bigger, at about 4000 ft altitude somewhere near ORTAC, not more than about 15nmi away.

4 See *Section 3* for a reconstruction of times and distances based on Jersey ATC radar plots.

At 14:09:32Z, after about 3 min observing with binoculars, the object was still ahead of the aircraft, just a few degrees to the right of the nose, and Capt Bowyer now radioed Jersey Control Zone on 125.2MHz. He asked the controller, Paul Kelly, “Do you have any traffic, can't really say how far, about my 12 o'clock, level?”

Kelly replied, “No, no known traffic at all in your 12 o’clock”.

“Roger,” replied Bowyer, “I've got a very bright object . . . extremely bright yellow, orange object, straight ahead, very flat platform, looking at it through binoculars as we speak.”

Immediately Kelly responded that he did now have “a very faint primary contact”, 11 o’clock at 4 miles from the aircraft. Bowyer acknowledged.

After half a minute Bowyer again asked Kelly, “any more information on that aircraft please?”

There was still a primary contact on the left of the Trislander, said Kelly, now 10 o'clock at a range of 3 miles, but nothing that appeared to correspond to the visual UAPs. Kelly thought the contacts might be false echoes caused by anomalous propagation.

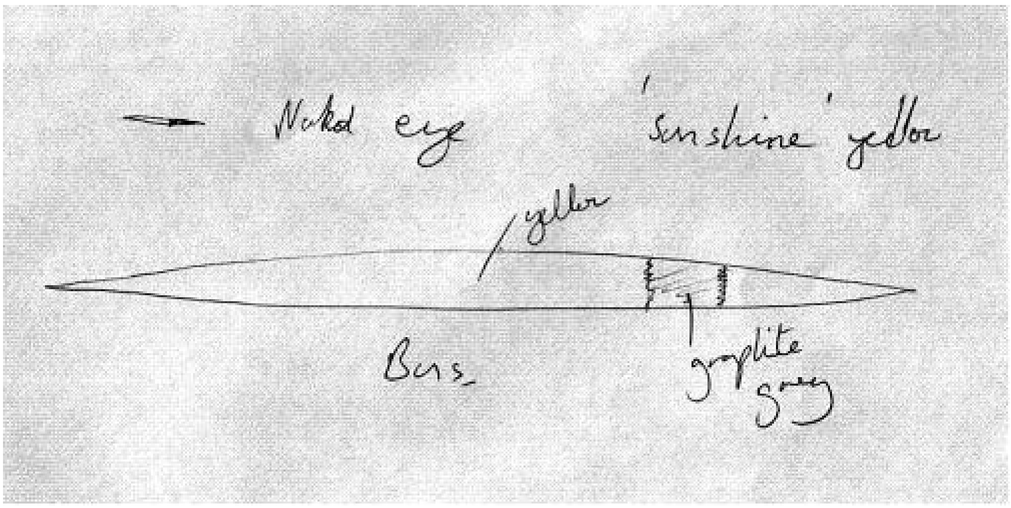

Fig 3. Drawing by Capt Bowyer in interview with Paul Fuller, 8 July 2007. Showing binocular appearance (centre) of one of the two identical objects compared with its naked eye appearance (upper left)

At about 1412:30Z Capt Bowyer crossed the 50° parallel of latitude and passed left abeam the ORTAC reporting point. At about this time he noticed a second object (UAP #2) a little to the right of the first, and at slightly higher elevation, as shown in *Fig.4*. This one was identical in appearance including the golden yellow colour and asymmetrical graphite-grey band, except that #2 looked smaller, was a little less bright and seemed further away. Both objects were seen to the W of Alderney and to the right of the aircraft flight track, but to the left of the Casquets lighthouse[5], which at this time was visible about 12° to the right of the flight line. They were both visible simultaneously in the same binocular field of view, laterally separated by only a degree or so.[6] "As the flight continued," emphasised Capt Bowyer, "the second appeared above the first, whereupon finally the second appeared to the *left* of the first [UAP] at last sighting."[7]

He reported the appearance of this second object to Jersey ATC at 1414:04, and observed that they both appeared to be somewhere west of Alderney. Seconds later at 1414:23 the Controller replied that a primary radar contact was now showing in the area of the Casquets. Capt Bowyer replied that this possibly corresponded with the position of UAP#2.

As the Trislander continued in flight towards Alderney three changes happened: The UAPs changed their bearings relative to one another; they changed their elevation relative to the horizon; and their angular sizes increased.

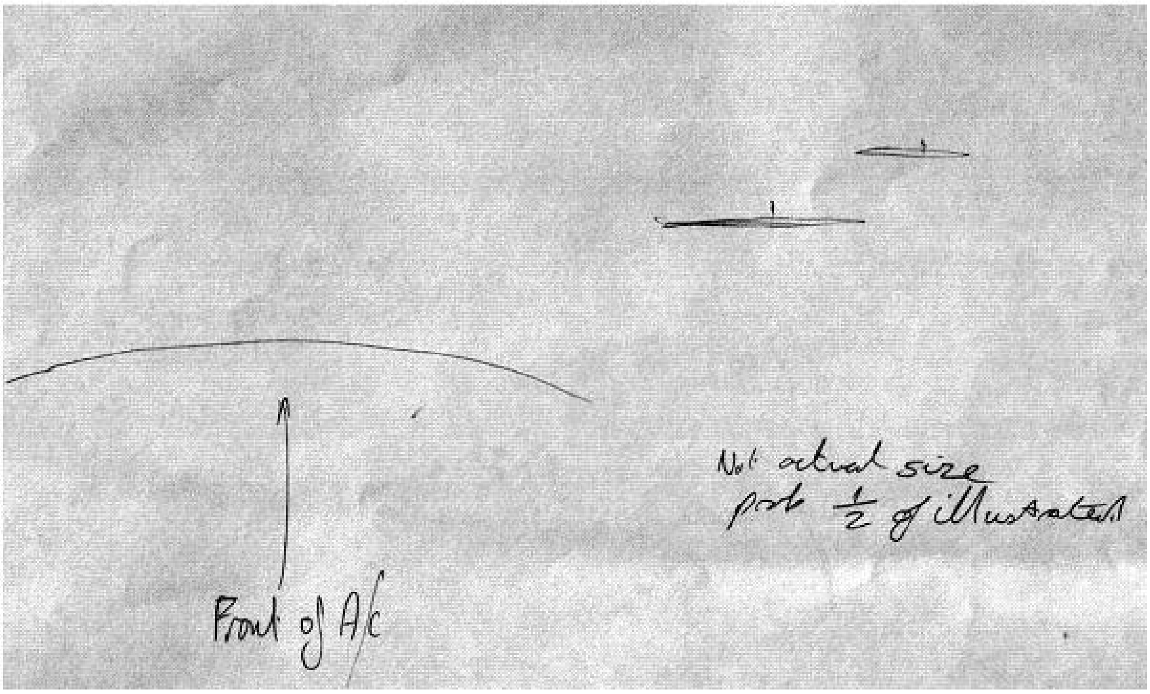

Fig.4 Drawing by Capt Bowyer, 8 July 2007, indicating size and position of UAP #2 (right) when first seen, relative to UAP #1 (left) and the nose of the Trislander.

By approximately 1416Z, as the plane was about to begin its turn towards Alderney, the two UAPs had closed their lateral separation and appeared "lined up" one directly above the other. Also at this time the line of sight to the UAPs had fallen slightly below the horizontal, so that just before beginning the descent from FL40 Capt Bowyer estimated that they appeared at a shallow

5 Casquets is a small islet at 49 43'42"N 02 22'42"W according to Trinity House records. Examination of the location on Google Earth discloses only a patch of darker sea colour that possibly indicates the rising underwater contours, i.e. the seamount of which Casquets is the exposed summit. The Casquets Light itself should not be confused with the sandbanks and reefs S of the lighthouse which are also known as the Casquets.

6 The binocular FOV at 10x magnification is estimated to be approximately 6°.

7 Email to Martin Shough 09.06.07.

depression angle of about -2°, against the sea.

As the plane descended and turned to the left, further away from the line of sight, the elevation angle rose back towards the horizontal and UAP #2 continued its relative drift to the left of #1, i.e., reversing their original relative bearings. When the plane reached the haze layer at about 2000ft. the UAPs appeared at 0° relative elevation, their angular sizes had increased by almost a factor 3 (so that #1 was now 15-18 mm at arm's length, or ~ 1.25°), and UAP#2 had moved across so that it lay perhaps 2° to the left of #1.

The time now was approximately 1418 as the plane descended into the haze layer where visibility dropped to a few miles and both UAPs were lost from sight (see *Appendices A & B*).

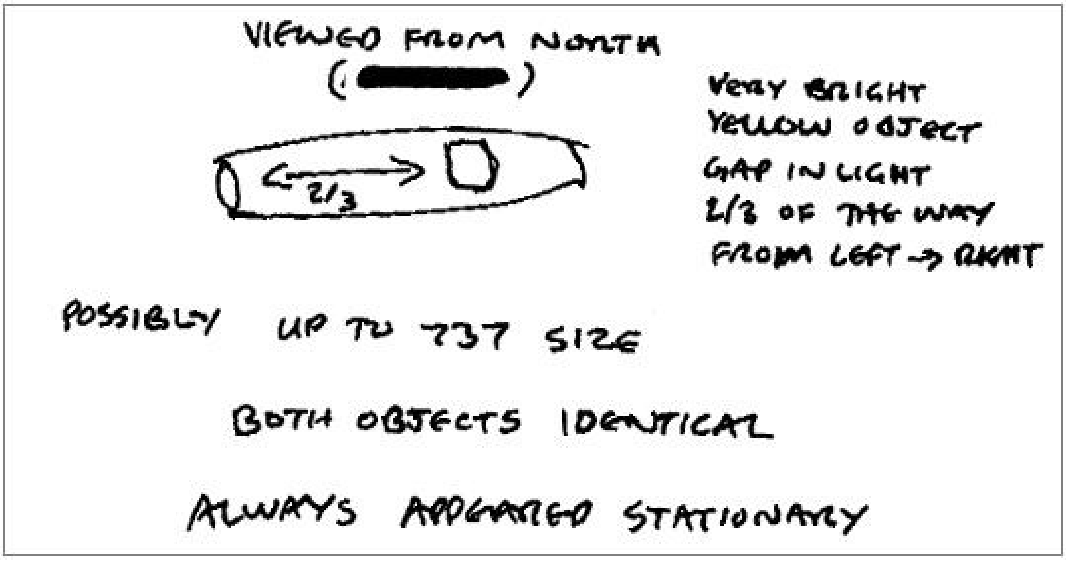

Fig.5 Controller Paul Kelly drew this impression from Capt Bowyer's real-time description via radio. Kelly notes that this was done before he had received a copy of Capt Bowyer's own illustrated report by fax at 1600Z, 23 April (Appendix A).

<u>Passenger observations</u>

One or both UAPs were seen by several (possibly as many as nine) passengers on board the Trislander. The flight deck area is not enclosed, but forward visibility from passenger seats further back is limited by other passengers, the high instrument fascia, windscreen frames and the pilot himself.

A single male passenger seated immediately behind Capt Bowyer was able to see both objects, with the naked eye and with the use of Capt Bowyer's binoculars, and a couple seated in the next row also witnessed all or part of the event. But these witnesses have so far declined to be identified.

Another couple was seated three rows back, John and Kate Russell from Alderney. John Russell's view was the more restricted but by leaning across his wife's seat he could see one of the objects through the cockpit windscreen, describing it as "an elongated oval" or "lozenge-shaped" and "brilliant orange" brighter than any reflection of the sun could be. He stated that he thought this object moved a little to the West (right).during the time it was visible.

Kate Russell had the better view. She was diverted from her book by noticing that the pilot had turned to talk with the passenger immediately behind him - something she had never seen happen before - and both appeared to be looking at something. This went on for a while and more passengers began to react,[8] but still nothing was visible from her position until the pilot dropped the nose of the plane at the start of the descent. The radio transcript (*Section 2*) and Jersey radar plot (*Section 3*) indicate that this was at very shortly after 1415:30Z. Soon after this time she was able to see two very bright "cigar"-shaped lights ahead of the plane, one larger than the other but both "sunlight coloured".

They were below the horizon (Capt Bowyer's report mentions that the UAPs had reached a maximum depression angle of -2° just before this point in the flight). She thought initially that one object (the small one) was above Alderney[9], the other over the sea, seeming larger and nearer. After a short while she lost sight of them as the plane's nose came up briefly. Then as the nose dipped again in the continued descent towards Alderney they reappeared. This time the yellow hue of the lights was more distinct, but she disputed her husband's description of an "orange" colour (claiming that John was colour-blind!) although the word "orange" was also used by Capt Bowyer.

Both witnesses disputed Capt Bowyer's later public opinion (based on a revised impression of range) that the objects might have been thousands of feet across. Kate had no definite impression of size, but felt that they were "nothing like as large", the nearest seeming to be perhaps 10 miles away, between the plane and Alderney. John had the impression that the object he saw might have been smaller than the Channel merchant vessels they saw during the flight. In other words, their visual judgments at the time were not dissimilar to Capt. Bowyer's.

(see *Appendix B*)

b) Blue Island 832 (BAe Jetstream 32)

At approximately 1412Z Capt Bowyer asked Jersey Zone controller Paul Kelly if anyone else was seeing the object (at this time only UAP #1 was visible). Kelly replied that he had "nothing really in the area", but called a BAe Jetstream 32 turboprop passenger aircraft of Blue Islands airways (BCI832, Sqk. 7770) cruising at about 250 knots SE-bound past Guernsey *en route* to Jersey from the Isle of Man. In charge of this aircraft was Capt Patrick Patterson, a pilot with several thousand hours experience (in excess of 2500 hrs in the command seat) who had been flying routes in the Channel Islands area for approximately one year.

Kelly asked: ". . . in your left, just behind 9 o'clock, can you see anything in that direction?"

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[8] Capt Bowyer states that he did not himself draw his passengers' attention to the objects. They spotted them independently.

[9] At first sight this is in conflict with Capt Bowyer's observation that sightlines to both objects were to the right of the flight track. Alderney was at this time to the left of the flight track. The explanation for this is discussed in *Section 3*.

Capt. Patterson, who had overheard the previous exchanges, replied, "I'm having a look, stand by." A minute later the pilot replied that he could see nothing at all in that position, and at 1413:24 Kelly handed off Blue Island 832 to Jersey Approach.

However very soon after this at 1414:43 the pilot radioed Jersey Approach, explained the situation and stated that "I've got something about 8 o'clock resembling the description".

From a point close to the island of Sark (E of Guernsey)[10] the Jetstream pilot looked back over his left shoulder towards Alderney and now saw in his 8 o'clock position what he described in a written report the following day (see *Appendix A*) as an object fitting Capt. Bowyer's description and having a "yellow/beige" colour, apparently 2000ft below him at about 1500 ft altitude a little to the W or NW of Alderney about 20 NM away.

Subsequent questioning (*Appendix B*) established that this object appeared "oval" or "oblong" and its outline was very hazy, just a patch of yellow coloration comparable to the paint colour of an Aurigny Trislander fuselage (a bright canary yellow) as seen in hazy conditions at distance. It appeared to be approximately 2 NM to the west of Alderney (visible in outline through haze together with nearby Burhou) and, by comparison with the island, would have had a *maximum* horizontal dimension of about 0.5 NM (900m; Alderney, in this perspective, would have subtended about 7° in width from 20NM range, indicating a maximum angular width of about 1.3° for the object, or more than twice the apparent diameter of the moon). It did not appear to move.

Visibility was "fairly poor" due to the haze layer below his altitude but the pilot saw this object several times in between brief interruptions due to flight deck duties. After approximately 1 minute he looked back and had lost visual contact.

(see *Appendices A and B*)

c) FlyBe Jersey 912G (BAe 146)

At 1413:33, immediately after receiving the Jetstream's initial negative reply, Paul Kelly contacted the pilot of a FlyBe BAe146 northbound from Guernsey to Gatwick whose flight path had crossed behind the Jetstream and would take it NE towards R41 on a course reciprocal to that of Capt Bowyer's Trislander. Kelly advised that the object "… would be roughly on your course towards ORTAC, probably below, could you advise us if you see anything in the vicinity of Alderney?"

At about 1414 Kelly was advising Capt Bowyer that he had a primary echo possibly corresponding to UAP #2 near the Casquets. Seconds later - at almost the exact moment that the Blue Islands Jetstream was reporting on the Approach frequency that he had a an object in sight near Alderney - Kelly called the 146 which was now flying west of the location and advised that "there is a primary [radar echo] just on your right hand side now, vicinity of the Casquets, about a mile to your right." The pilot indicated that he would look. However at about 1417:30 after a

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[10] This is not the exact location recorded by Jersey Air Traffic Controller Paul Kelly in his CAA report, neither is it the location given in the pilot's own CAA report. For discussion see *Section 3*.

second query from Kelly - "anything down your right hand side this time?" - the pilot responded that he had seen nothing, and thereafter was handed off to London Air Traffic Control for his cruise.

In radio discussion with Capt Bowyer during the latter's return flight to Southampton, Kelly remarked: "I think the FlyBe was too high". Capt Bowyer recalled that the BAe146's altitude was between 6000 and 8000ft.

(see *Section 2*)

d) Golf Romeo Romeo

An unidentified aircraft with the call sign GRR was heading southbound probably on R41 approximately 18nmi behind the Trislander (a few miles past ORTAC) when the pilot was contacted by Jersey Zone at about 1418. This was just as the sighting was ending. GRR was asked if he had overheard the transmissions from the Aurigny aircraft and replied in the affirmative. Controller Kelly asked him to keep an eye out as he approached and passed down the E side of the island of Alderney. GRR acknowledged. Queried at 1432 when off Alderney the pilot responded that - "to my disappointment" - he had seen nothing.

(see *Section 2*)

* * *

No other aircraft were in the area during the time of the sighting.

2) Transcript of Radio Communications

Jersey ATC kindly provided wav. files of all air/ground radio communications involving Channel Islands Control Zone and Jersey Approach Control during approximately two hours after the start of the sighting time. All exchanges on three ATC frequencies with reference to the UAP sighting have been extracted and transcribed below against time of transmission, beginning with Capt Bowyer's first call to Jersey Zone at 1409:32. Refer to radar map, *Fig.6*.

Jersey Control Zone frequency, 125.2 Mhz:

JZ = Jersey Control Zone
AL = A-Line 544 = Aurigny Airlines 544
BI = Blue Island Airways 832
JG = Jersey 912 Golf.

1409:32, AL: Jersey Zone, A-Line 544.

1409:37, JZ: A-Line 544, pass message.

1409:40, AL: Do you have any traffic, er, can't really say how far, about my 12 o'clock, er, level?

1409:50, JZ: Er, no, no known traffic at all in your 12 o'clock.

1409:54, AL: Roger, I've got a very bright object, er, [unintelligible word], well, as I say it's difficult to say how far, extremely bright yellow, orange object, straight ahead, er, very flat platform, looking at it through binoculars as we speak.

1410:10, JZ: A-Line 544, rog, I do have a, er, primary contact now, er, very faint primary contact, just to the left probably to your 11 o'clock this time and a range of, er, about 4 track miles.

1410:31, AL: Roger.

1411:07, AL: A-Line 544, any more information on that aircraft please?

1411:11, JZ: A-Line 544, er, negative, there's just a primary contact [that/but?] we sometimes get anaprop on the radar. There is something possibly your left, er, 10 o'clock at a range of 3 miles this time.

1411:26, AL: I've got a definite contact, my 12 o'clock, very bright yellow object looking like, well, a cigar.

1411:38, JZ: A-Line 544, er roger, nothing at all in your 12 o'clock, erm, for the next 40 miles or so.

1411:47, AL: Roger 544. Anyone else see that?

1411:51, JZ: There's, er, nothing really in the area - Blue Island 832, er Zone?

1411:57, BI: Er, go ahead, what's the position of, er, the A-Line? ?

1412:00, JZ: Er, that traffic is in your left, just behind 9 o'clock, can you see anything in that direction towards [Ortac/ORTAC] ?

1412:07, BI: I'm having a look, stand by.

1412:28, JZ: A-Line 544, er there's still nothing seen, could you confirm this traffic is at a similar level to yourself?

1412:36, AL: Roger 544, just confirming, now all the passengers can see this . . . aircraft, er. I've got the island visual, it's dead ahead, can't say how far, probably 5 miles, but it's staying the same size, er looks to be off the north . . . north-north-west coast of Alderney [break in transmission] over Burhou-ish at the moment, but I can't really tell.

1412:58, JZ: A-Line 544, er, roger, we'll try and get hold of Alderney tower, see if they can, er see anything.

1413:03, AL: Roger.

1413:05, BI: Blue Island 832, I can't see anything in that, er, position.

1413:09, JZ: I think we crossed there, say again.

1413:13, BI: It's Blue Island 832, er, I - I have nothing in that, er, position at all I can't see anything.

1413:16, JZ: Blue Island 832, roger, descend Flight Level 40.

1413:22, BI: Descending Flight Level 40 Blue Island 832.

1413:24, JZ: Blue Island 832, contact Jersey Approach now, 120 decimal 3.

1413:30, BI: Jersey Approach, 120 decimal 3, Blue Island 832.

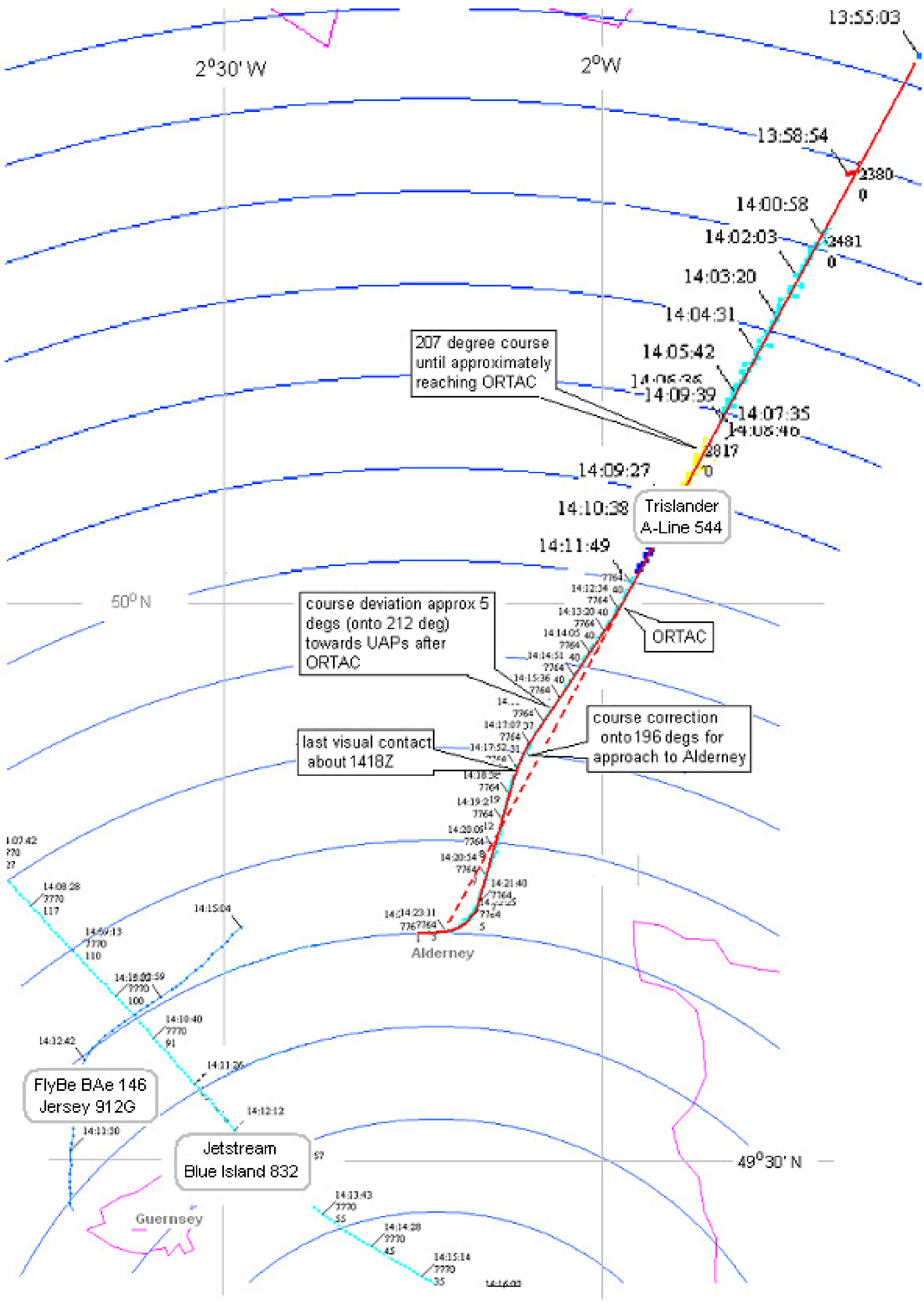

Fig. 6 Map based on merged ELVIRA images from Jersey ATC showing Trislander, Jetstream and BAe146 *courses. A best-fit to the* Trislander *radar plot (solid red line) is shown compared with a straight 207° heading (broken red line). Range rings are at 5nmi intervals.*

1413:33, JZ: Jersey [912?] Golf, Zone?

1413:35, JG: Go ahead, Jersey 912 Golf.

1413:37, JZ: Have you been listening in to the conversation with the A-line?

1413:39, JG: Affirm, Jersey 912 Golf.

1413:41, JZ: Roger, that, er, object would be roughly on your course towards ORTAC, probably below, could you advise us if you see anything in the vicinity of Alderney if you look down at all?

1413:53, JG: Er, we'll keep a visual eye out, Jersey 912 Golf.

1413:56, JZ: Roger.

1413:59, AL: A-Line 544, er Jersey.

1414:02, JZ: Pass message.

1414:04, AL: Well, looking through binoculars as I am now, er, there's a second one just appeared behind the first one, um, from where I am.

1414:12, JZ: A-Line 544, roger, and er, are they still between yourselves and Alderney?

1414:16, AL: Negative, I think over maybe to the west of Alderney.

1414:23, JZ: Roger . . . erm, I do have a primary contact, just one . . . blob if you like, er, 8 miles or so to the west of Alderney in the vicinity of the Casquets.

1414:36, AL: That would possibly be the second one, furthest out that I can see. The first one is maybe closer, looks like Burhou area or beyond Burhou from me in a straight line.

1414:47, JZ: A-line 544 understood, break. Jersey 912 Golf, that would be roughly below your position this time.

1414:55, JG: Rog, this is Jersey 912 Golf, still looking, er, I can't see anything.

1414:58, JZ: Roger, there is a primary just on your right hand side now, erm, vicinity of the Casquets, about a mile to your right.

1415:07, JG: Roger, Jersey 912 Golf, just looking.

Jersey Approach frequency, 120.3MHz *(overlapping previous exchanges with Zone on 125.2 Mhz)*

BI = Blue Island Airways 832
JA = Jersey Approach Control

1414:43, BI: Jersey, Blue Island 832. Zone asked us to look if we could see an object which is, um, being seen by A-Line at the moment, I've got something about 8 o'clock resembling the description.

1414:55, JA: Blue Island 832, roger, what range would you estimate that target?

1414:59, BI: Around about a similar range to Alderney from us now.

1415:04, JA: Blue Island 832, and at the same level, or lower or higher?

1415:08, BI: Er, lower, I would suspect about 2000 lower.

1415:12, JA: Blue Island 832, roger.

Jersey Control Zone frequency, 125.2 Mhz:

JZ = Jersey Control Zone
AL = Aurigny Airlines 544
JG = Jersey 912 Golf
GR = Golf Romeo Romeo
SL = Sky Elite 597 Papa
511 = Jersey 511
03 = 03
GC = Golf Charlie Sierra

1415:13, AL: Yeah, the second one appears to be beyond the first from where I am, in other words towards the south west. Er, it's exactly the same, it's got a gap. It's a cylindrical . . . object, very bright yellow, and there's a gap in light about two thirds of the way along it from, er, left to right as I look at it, and the second one is exactly the same.

1415:33, JZ. A-Line 544, roger, would you like descent.

1415:36, AL. Please, I better had go down I think.

1415:38, JZ: A-Line 544, as you descend towards 2000ft the QNH is 1021

1415:43, AL: Descend 2000 feet, 1021, they're very plain to see from where I am now, without, er, any binoculars.

1415:49, JZ: Roger.

1416:31, JZ: A-Line 544, er, anything more?

1416:35, AL: Er, certainly two objects now, passengers can both . . . see, or passengers can see two objects. I'm going to be in a straight line with them on, er, sort of final approach into Alderney. Two very bright lights.

1416:47, JZ: Roger. Have you any idea of the scale of them?

1416:49, AL: Er, I'd say, from here, difficult to say how far away they are, I'd say the furthest one is 10 miles away, closest one is 4 miles away, 5 miles away, maybe 7, erm, don't know, like - the size of 737, something like that?

1417:06, JZ: A-Line 544, Roger.

1417:09, AL. Both stationary.

1417:10, JZ: Roger. And, er, what sort of level?

1417:14, AL: Low to me now, er, I'd say 2000 feet, 1500.

1417:19, JZ: Roger.

1417:28, JZ: Jersey 912 Golf, anything down your right hand side this time?

1417:32, JG: Er, negative, Jersey 912 Golf.

1417:35, JZ: Jersey 912 Golf, er, roger, contact London now, 132 decimal 3.

1417:39, JG: 132 decimal 3, Jersey 912 Golf.

1417:42, JZ: Golf Romeo Romeo, Zone.

1417:44, GR: Er, Golf Romeo Romeo Golf?

1417:46, JZ: Er, have you been listening in on the conversation with the A-Line?

1417:49, GR: Affirmative.

1417:51, JZ: Do you know that traffic is about 18 miles ahead of you this time, if you could keep me advised if you see any objects on your way towards Alderney.

1418:00, GR: Er, Golf Romeo Romeo, will do.

1418:02, AL: A-line 544, I've lost the objects now in the haze in descent.

1418:06, JZ: A-line 544, that's copied.

1418:35, JZ: A-Line 544, we've advised, er, Guernsey and they've advised Alderney about, er, whatever that is. You can call them now on 128 decimal 650.

1418:43, AL: Roger, thanks, A-line 544.

1423:55, JZ: Sky Elite 597 Papa, when ready descend Flight Level 50.

1423:59, SL: When ready descend Flight Level 50, Sky Elite 597 Papa.

1424:03, JZ: Sky Elite 597 Papa, er I think this happened before you were on-frequency but some previous traffic into Alderney reported seeing some unidentified objects [laughs at unheard comment] in the sky in the vicinity of Alderny. Could you advise me if you see anything?

1424:20, SL: [unintelligible] Sky Elite 597 Papa.

1424:24, JZ: What you're looking for would be cigar-shaped very bright yellow objects emitting light.

1424:34, SL: Er, yeah, yeah [laughing] we'll, er, keep a good look-out, Sky Elite 597 Papa.

1424:39, JZ: [unintelligible] we had a Trislander into Alderney over a period of about 10,15 minutes, all the passengers saw the objects as well, there were two in the vicinity of Alderney and one at the Casquets.

1424:52, SL: [unintelligible] and we are visual with Alderney at the moment, keeping a good look-out, Sky Elite 597 Papa. [unidentified voice: ". . . trying, it's such a laugh!"]

1424:59, JZ: Thank you.

1427:49, JZ: Sky Elite 597 Papa. If you can keep a good look-out, er, on your way down and advise Guernsey if you see anything, 128 decimal 650.

1427:57, SL: OK, and Guernsey 128 decimal 650, Sky Elite 597 Papa.

1428:08, JZ. Golf Romeo Romeo, Zone.

1428:10, GR: Er, Golf Romeo [unintellible].

1428:13, JZ: If you could keep a good look out as you pass down the side of Alderney, er, towards Alderney and the west. We've a cross-reference from some traffic inbound to Jersey from the south which saw the objects from the vicinity of Sark towards Alderney at the same level.

1428:28, GR: Er, Golf Romeo, we copied all that, keeping a good look out, certainly.

1428:31, JZ: Thankyou.

1432:11, JZ: Golf Romeo Romeo, you're passing down the east side of Alderney now, er, anything seen at all?

1432:16, GR: Er, Golf Romeo Romeo, to my disappointment, nothing.

1432:21, JZ. Golf Romeo Romeo roger maintain altitude 3000 feet continue with Jersey approach 120 decimal 3.

1432:28, GR: 120 decimal 3 maintaining 3, thankyou.

1432:30, JZ. Bye bye.

1432:31, GR: Bye bye sir.

1436:39, JZ: 511 Jersey?

1436:40, 511: 511 go ahead.

1436:41, JZ: Er, if you can just bear with me a bit whilst I explain this to you, we had an A-line who landed in Alderney about 20 minutes ago, er, he reported two cigar shaped objects, bright orange, approximately, well, between 5 or 40 and surface level just off the NW corner of Alderney, so if you could keep a look out for anything at all on your way down to Guernsey.

1437:05, 511: Yeah, will do, sounds very strange, maybe there're UFOs in the area.

1437:10, JZ. Yes, maybe indeed, er, the pilot reported it and, er, all the passengers saw it as well. And, er, we had a separate, er, aircraft [unintelligible] just east of Sark who also confirmed it north of his position, so like I say, if you could keep a good look-out and advise us if you spot anything.

1437:23, 511: Wilco, thankyou.

1437:29, JZ: [unintelligible] 03, did you copy that?

1437:30, 03: [unintelligible] 03, we'll keep an eye out.

1437:31, JZ: Roger.

1440:31, JZ: Jersey 511, continue again to your approach 128 decimal 650 and if you could advise them if you do spot anything on the way down

1440:38, 511: 128.650, wilco, Jersey 511, bye - not seen anything yet.

1440:42, JZ: Bye bye, cheers.

22120.3MHz, Jersey Approach frequency:

GC = Golf Charlie Sierra
JA = Jersey Approach Control

1441:46, JA: Golf Charlie Sierra, Approach

1441:50, GC: Approach, Golf Charlie Sierra

1441:52, JA: Golf Charlie Sierra, for your information we've had some reports of some strange objects in the vicinity of Alderney in the past 35 minutes, at the same level as yourself, so if you could keep a good look-out towards Alderney and advise if you see anything.

1442:04, GC: Er, wilco, Golf Charlie Sierra.

Jersey Control Zone frequency, 125.2 Mhz:

JZ = Jersey Control Zone
PH = Papa Hotel Bravo
511 = Jersey 511
932 = Beauport 932

1443:18, JZ: Papa Hotel Bravo, Jersey Zone?

1443:21, PH: Go ahead.

1443:22, JZ: Papa Hotel Bravo, um, approximately 20 minutes ago we had a Trislander landing at, er, Alderney. He reported seeing, er, two, erm, cigar shaped objects apparently off the northwest coast of Alderney. It was confirmed by another aircraft and the passengers on board. I was just wondering if you could see anything from your present position towards Alderney?

1443:46, PH: OK, we're looking.

1443:48, JZ: Beauport 932 did you copy that?

1443:53, 932: Affirm, 932.

1443:56, JZ: Yeah, it was just to the west of, er, Alderney, they were between Flight Level 40 and surface level so I mean if you could, or if you do see anything at all if you could report back?

1444:05, 932: Roger

1446:51, JZ: Papa Hotel Bravo, anything seen at all to the east of you?

1446:54, PH: No, had a good look, nothing observed.

1446: 59, JZ: Papa Hotel Bravo, roger, thanks for that.

1525:01, JZ. Hello A-Line 563, Zone.

1525:03, AL: Go ahead please.

1525:04, JZ. Er, I believe my colleague wants to have a quick, er, word with you, so when you have the chance if you could, um, contact him on 118 decimal 550.

1525:13, AL: 18 55, coming across now.

Jersey Control Zone spare frequency, 118.55MHz

JZ = Jersey Control Zone
AL = Aurigny Airlines 563

1525:22, AL: This is A-Line 563 on 118 55 box 2.

1525:26, JZ: 563, hello. Er, we were talking before when you were southbound reference the objects - um, I've spoken to your Ops in Alderney, they faxed me through a copy of your flight log, I believe, with the diagrams on. I was wondering if when you get a moment you could take - write down whatever details you can, er, draw the diagrams or whatever and then fax them through to us here at Jersey?

1525:51, AL: Roger, wilco. Have you got a telephone number?

1525:55. JZ: Yeah, it's ----- --- ---.

1526:04, AL: That's --- ---.

1526:08, JZ: That's correct - and, er, for the attention of myself, that's Paul Kelly.

1526:16, AL: Paul Kelly, wilco. Er, any other sightings? I understand a FlyBe got it.

1526:20, JZ: Er, well . . . the FlyBe 146 I think was too high, but, er, a Blue Island Jetstream passing, er, down abeam Sark on its way down to us, once it was at a similar level I think, 450, saw the objects - er, opposite direction to yourself in the vicinity of Alderney, estimated range from them about 10 miles.

1526:44, AL: Roger, thanks very much. Did he see two objects like I did?

1526:48, JZ: Er, he didn't say actually, um, we can double-check that, but he certainly saw one in the vicinity of Alderney, perhaps the other one, if it was further west, would have been actually behind him as he was heading down to us.

1526:59, AL: Yeah, that would confirm what I saw. Thanks very much, I'll be in touch by fax.

* * *

3) Detailed Reconstruction of Sighting Geometry

Prior to obtaining the complete Jersey ATC radar data for the sighting period[11] we were able to study several composite screenshots produced by the ELVIRA[12] software. Most importantly these showed secondary radar plots during the sighting period aggregated onto single images at various scales, enabling us to identify and map accurately the courses of the several aircraft involved. The true altitudes and the instant pitch and yaw of the Trislander (which are not necessarily identical with the course and slope of the flight track) will also assume importance in an accurate 3D reconstruction of lines of sight.

At the time of the initial call to Jersey (14:09:33Z) the Trislander had not yet entered the Channel Islands Control Zone, but had been visible for some minutes on Jersey radar with the "squawk" number (transponder code) 7764 and the altitude report "40[hundreds of feet]".

Capt. Bowyer initially estimated (see *Section 1*) that UAP #1 was near the ORTAC reporting point and no more than about 15nmi from the aircraft. The radar plot shows that the Trislander was 15nmi from ORTAC at approximately 1404:30. According to Kelly's written report the first sighting was at 1409, when 5-10nmi from ORTAC. However Capt Bowyer estimated that 2-3 min passed before his first message to Jersey Control, which is timed on the ATC audio log (*Section 2*) as 1409:33 when the radar plot is at about 5-6nmi from ORTAC. These figures cannot be exactly reconciled. The best-fit approximation is that the first sighting occurred when at a position about 12nmi from ORTAC at 1406Z, ~3.5 min before the first radio call to Jersey ATC.

Paul Kelly records the reported time of sighting of UAP #2 as 1416, which is in conflict with the time of 1410 handwritten on Capt Bowyer's CAA report.[13] 1416 is also in conflict with Capt Bowyer's statement that UAP #2 was first seen when the plane reached the approximate position of the ORTAC reporting point, since the radar plot shows that this occurred a little after 1412. Given a normal degree of narrative approximation "1410" can probably be reconciled with 1412-13 (at 1410 the plane was a few miles and a couple of minutes from ORTAC at 115kt GS) being shortly before the appearance of UAP#2 was reported to Jersey Zone at 1414 (radio transcript, *Section 2*). The origin of Kelly's "1416" remains uncertain.

Another feature of the Trislander's radar plot is a small but quite noticeable drift from the nominal 207° heading on R41 to about 212° after ORTAC (*Fig.6*). We wondered if Capt Bowyer had disengaged the autopilot and turned towards the UAPs out of curiosity. Questioned about this Capt Bowyer stated that he did not recall having turned deliberately towards the objects at the time[14] and that the autopilot remained engaged continuously until about 1 mile from Alderney.

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[11] Thanks to the mediation of Capt Bowyer and the kind assistance of Jeremy Snowdon and Simon Langlois of Jersey ATC. See *Section 4*.

[12] *E*nregistrement, *L*ecture et *V*isualisation d'*I*nformation *RA*dar is the French industry standard format for ATC radar data management used also by Channel Islands ATC.

[13] Capt Bowyer's report contains handwritten annotations by an Alderney Flight Operations official (name blacked out) on this same page. The time of 1410 appears here in notes written "after conversation with [Capt Bowyer]", as well as next to Bowyer's drawing. It may be that the Ops official is responsible for both entries although this is unclear.

[14] He considered doing so, as he told the *Guernsey Press & Star (26.04.07):* "As I got closer to it, it became clear to me that it was tangible. I was in two minds about going towards it to have a closer look but decided against it

He suggested that he may have rotated the aircraft slightly, without disengaging the autopilot,[15] perhaps because the wide windscreen divider was obscuring his view of UAP#1.

It was possible to correct an unexplained error in the 1420Z landing time given in the CAA report. At 1420 the Trislander was still above 800 ft and about 5nmi N of Alderney. The final radar plot indicates that touchdown on the tarmac of runway R26 was after 1423.[16]

Examination of the radar plot also discloses an ambiguity in the recorded altitudes, which are based on SSR transponder reports of the plane's pressure altimeter reading. These appear on-screen graduated in steps of 100ft from "40" down to the final reading of "1" (=100ft) at touchdown. At first sight this is confusing since runway R26 at Alderney airport is at about 290 ft elevation. The reason is that these are reports from the plane's pressure altimeter, not true altitudes ASL, and require adjusting according the difference between the standard flight level pressure calibration (QNE) and the local pressure (QNH).

The radar plot of the Blue Islands Jetstream also allowed some previous confusion to be resolved. The location recorded by Jersey Air Traffic Controller Paul Kelly in his CAA report was about 5nmi northeast of Sark, which is in conflict with the pilot's own report to CAA giving 5nmi north*west* of Sark. Examination of the radar recording shows that the Jetstream was never at any time 5nmi northeast of Sark. It did pass close to 5nmi northwest of Sark, but shortly after 1412Z when its altitude was about 6500ft. The radio transcript (*Section 2*) proves that the pilot had the UAP under observation some 3mins later, at 1414:43 and probably until at least the end of his transmission to Jersey Approach at 1415:12, which suggests a position approximately 3nmi due E of Sark. Of course the aircraft is travelling SE at ~ 4.2nmi/min and descending, so the change of position is substantial during the estimated duration of about 1 minute. At 1414:43 the radar plot indicates a pressure altimeter height of about FL42, or possibly ~ 4400ft ASL when corrected for QNH of 1021mbar. If the report was made near the beginning of the observation then it would terminate near FL29 at 1415:43, or about 3100ft ASL. This seems consistent with the pilot's later report of "passing through 3500ft" at the time.

We now wish to integrate the radar track and height information with the timed transcript of radio communications given in *Section 2,* and the witness narratives summarised in *Section 1*, in order to evolve the sighting geometry in three dimensions. From this we will attempt to measure accurately the azimuth and elevation angles of the different lines of sight (LOS).

As already mentioned, the indicated radar altitudes are produced from SSR transponder reports based on the international standard altimeter pressure setting. The Trislander's cruise altitude, for example, appears as "40" on the radar plot. This stands for Flight Level (FL) 40, which means that the altimeter is reading 40 hundreds of feet or 4000 ft above a notional sea-level pressure of 1013mbar.[17] The true altitude ASL will be found by adding the equivalent height corresponding

because of the size of it. I had to think of the safety of the passengers first."

15 The CAA "Check Flight Certificate" form for the BN2A MK3 Trislander (CAA CFS 159 issue 1, Section 12.6) instructs that with the auto-pilot engaged a load is to be applied to each main flying control to ensure that the pilot is able to satisfactorily "overpower the auto-pilot."

16 A noteworthy feature of the logged flight times is that the Southampton-Alderney trip was 7min *shorter* than the previous Alderney-Southampton trip despite an adverse headwind. This was resolved by Capt Bowyer as being due to the miles consumed in overshooting Southampton and making a turn around for a landing headed SW.

17 There are several different types of aviation altitude measure and UK airspace has controlled and uncontrolled

to the pressure gradient between 1013mbar and the local surface pressure. This leads to a true cruise altitude of approximately 4216 ft ASL and all subsequent radar altitudes must be adjusted by the same +216ft.[18] (Thanks to the fact that FL1 corresponds to a true altitude of about 100 + (8 x 27) = 316 ft the last altitude report then places the Trislander about 30 (+/- 50) ft above the tarmac instead of 189 ft underground.)

Magnetic Track °	Cruising Level
More than 360 and less than 90	FL 30, 50, 70, 90 etc. up to FL190
More than 90 and less than 180	FL 35, 55, 75, 95 etc. up to FL175
More than 180 and less than 270	FL 40, 60, 80, 100 etc. up to FL180
More than 270 and less than 360	FL 45, 65, 85 105 etc. up to FL185

Table 1. Quadrantal Rule for flights at levels below FL 195.
Manual of Air Traffic Services, Sect.1, Ch.2, p.4, CAA March 2007

First consider the lines of sight shown in plan in *Fig.7*. This construction is dictated by certain constraints and assumptions coming from witness descriptions and sketches (see *Fig.10* & *Appendices A & B*), as follows:

1. The 1406 line of sight (LOS) to UAP#1 lies approximately 7° to the right of 12 o'clock from the Trislander ("slightly to the right", "a few degrees to the right", "5-10° to the right"[19])
2. Both LOS#1 and LOS#2 lie at all times to right of the flight track

sectors where conventions differ. Essentially, true pressure altitude (ASL) is used at low level, then there is a transition level, above which common calibrated pressure levels are used. Which convention is being used depends on where the transition level occurs, which varies from country to country and region to region. In uncontrolled UK airspace the transition level is normally 3000 ft. This is very much lower than in the US for example. The CAA Manual of Air Traffic Services gives the Quadrantal Rule for flight levels to use on different headings (*Table 1*) from which we can see that the Trislander's Flight Level in cruise as it approached the Channel Islands Control Zone was required to be FL40, 60 or 80 etc. All aircraft at a given Flight Level are thus actually confined on a common isobaric surface which preserves altitude separation regardless of local variations in atmospheric pressure. When descending through the transition level at 3000 ft the altimeter would be reset to the true local pressure (QNH) given to the pilot by ATC and it will then read true altitude ASL; however the transponder altitude reports sent to the radar will continue to be referenced to the FL pressure setting (QNE) of 1013mbar.

[18] Capt Bowyer stated, "The general average feet setting for one millibar of pressure increase is ~30ft, in fact the ICAO adjusted ft per mbar is 27ft. Obviously the height difference per millibar increases with altitude as pressure decreases. The standard pressure setting for all aircraft using flight levels is 1013mbar, so if the ambient sea level pressure is 1021 this equates to 8 mbar above Standard or 8x30ft or 4000 ft plus 240 ft. As altimeters are only accurate to +/- fifty feet this is deemed a sufficient rule of thumb adjustment." (email to Martin Shough, 05.08.2007)

[19] Over the radio Capt Bowyer initially described #1 as "in my 12 o'clock" and "dead ahead". Granting some approximation, clearly the angle is small and perhaps one feels it ought to be less than 7°. In fact when we allow for the crabbing angle of the aircraft due to the wind vector (see below) we find that the bearing of UAP#1 relative to the aircraft axis could be as small as about 3° and still be at 7° from the plotted course.

3. Both LOS#1 and LOS#2 pass to the left of the Casquets Lighthouse (Capt Bowyer). Casquets is ~12° right of the flight track after ORTAC)
4. Initially LOS#2 is approximately 1° to the right of LOS#1 (Capt Bowyer's drawing in *Fig.4* shows about one object width between object centres)[20]
5. By about 1416, both LOSs appeared to "line up"
6. By 1418 the LOS to #2 is about 2° - 3° to the left of #1
7. Also by 1418 the bearing of the LOS to the pair of objects had rotated to lie about 20° to the right of the flight track
8. Capt Bowyer judged that UAP#1 appeared to be approximately 2nmi S of the Casquets Light
9. Capt Bowyer judged that UAP#2 appeared to be approximately 10nmi SSW of UAP#1
10. Capt Bowyer judged that both UAPs were stationary (or very slow moving), and that apparent relative motions of both UAPs were parallax changes due to the motion of the Trislander

As can be seen by inspection of *Fig .7*, when these conditions are locked into the framework of the radar plot, with a freedom of only a degree or so, the result is a somewhat self-consistent triangulation of positions. There seems to be only one unique combination of lines of sight which satisfies in the simplest way, and with a very small margin of adjustment, the basic requirements of Capt Bowyer's observation. It is notable that the implied position of UAP #1 lies within a few degrees of the 8 o'clock position reported by the Jetstream pilot, Capt Patterson (the LOS to the second would have been too far behind the Jetstream).

We can go further. Between 1406 and 1418 the angular sizes of both UAPs grew larger. The estimated angular width of UAP#1 increased from ~0.5° to ~1.25°, corresponding to an enlargement factor of between 2.14 and 3.0.[21] The mean of these values (2.6) is very close to the ratio (2.8) of the two distances from the aircraft to the triangulated position of UAP#1 at these times. In other words, to an unusually good approximation, the apparent angular sizes increased by the factor that they should have done during the Trislander's approach if the UAPs were stationary objects of fixed real size at the triangulated locations.

During the time from 1413 to 1418 during which both UAP#1 and UAP#2 were visible their average distances from the observers are in the ratio 1**:**1.72. If both were the same physical size this would lead us to expect their angular sizes to be in ratio 1**:**0.58, or in other words that #2 would be slightly more than half the angular width of #1. Capt Bowyer estimated that "The second light was . . . slightly more than half . . . of the size of the first light" (Paul Fuller's interview). His sketch (*Fig. 4*) shows a ratio of 1 **:** 0.54.

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[20] A small angle is clearly implied in the real-time radio description (*Section 2*) and Capt Bowyer has explicitly confirmed that *Fig.4* shows how the UAPs were initially positioned. His Diagram 5 in *Fig.10*, suggests about 4° but this is only a schematic sketch. However Paul Fuller's interview (*Appendix A*), contemporaneous with Diagram 5, gives "perhaps 10 degrees" as the initial separation, which is clearly discrepant. Later discussion with Capt Bowyer suggests that this figure originates in a misunderstanding and was given as an estimate of the angle by which UAP#2 was offset from 12 o'clock, rather than from UAP#1. The original question - "Where was the second light in the sky ? Was it above/below/same level, to the left/right/straight ahead ?" - was arguably ambiguous as to the point of reference.

[21] Apparent sizes at arm's length, 6-7mm to 15-18mm at 75cm, were estimated during Capt Bowyer's interview with Paul Fuller at Southampton Airport, 8 June 2007

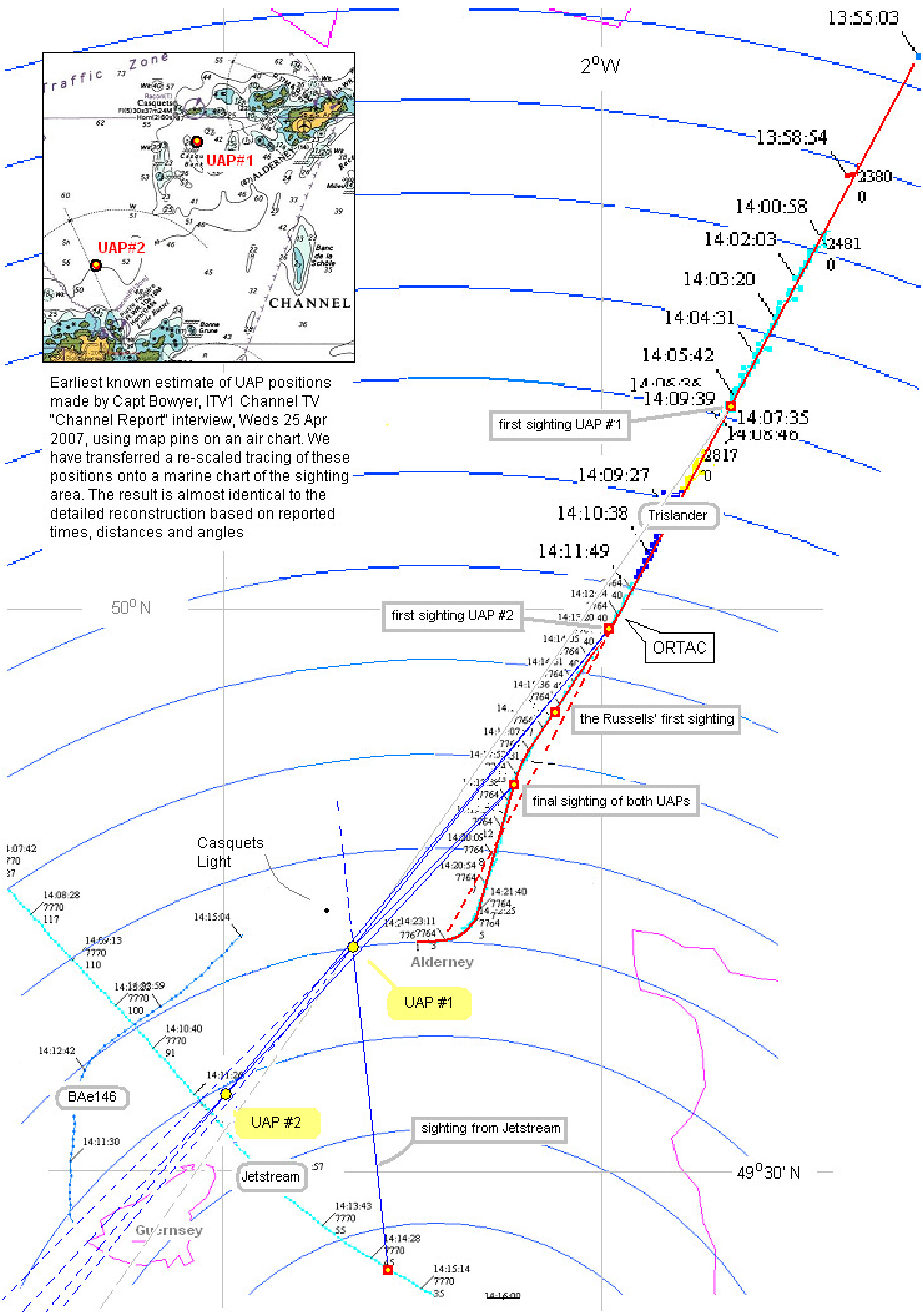

Fig 7. A first best-fit triangulation of possible UAP positions based on Trislander *and* Jetstream *observations. Range rings at 5nmi.*

(See http://video.aol.com/video-detail/2-pilots-spot-big-ufo-over-guernsey-uk-april-23-2007/597794936 for ITV interview)

The bearing of the objects relative to the aircraft changed significantly towards the end of the observation. The estimated 20° LOS rotation occurring before the final sighting time of 1418, as shown in Capt Bowyer's Diagram 5 (*Fig.10*), is quite closely reproduced in *Fig.7*, where it can be seen that at least part of this rotation[22] would be accounted for by the rotation of the aircraft coordinate frame during the start of the turn. The magnitude of the this component can be best gauged from the red curve in *Fig.9*, plotted by computer from the radar data, which shows that prior to visual loss (fixed by the radio transcript as being somewhat prior to 1418:03, the time of the transmission reporting it) the change of course can hardly have been more than a few degrees. The *maximum* course alteration approaches 16° only after another minute or more. Therefore we conclude that in addition to a small rotation of relative bearing there was a real rotation of azimuth, probably in the order of 10°. This is closely consistent with the angle (almost exactly 10°) measured between the initial (1406) and final (1418) LOSs in *Fig.7*, so that the sum of both components of bearing rotation is again consistent with parallax due to motion of the plane in relation to stationary objects at the nearby locations triangulated.

Looking at the third dimension of *Fig.7*, the descent slope of the aircraft taken from the radar plot is graphed in *Fig.8*. The angle increases fairly steadily from zero at a rate of ~10 arcsec/sec at 14:15:30 towards ~14° at 14:17:30, then sharply decreases at the same rate (i.e., the nose comes back up a little) for some 25 sec, reaching a plateau at around 9° for almost 40 seconds, then increasing sharply once more at ~14:18:40 for a final 23 sec towards a maximum depression angle of 25° at 1419 before levelling off to make the landing approach.

We know from the radio recording that the final visual loss in haze occurred at approximately 1418, so this curve fixes the Russells' second (and last) sighting in the dip, between about 1417 and 1418, when the slope steepens beyond about 10°. This occurs around the start of the turn from ~212° to ~190°. Kate Russell said that in this second sighting the UAPs' yellow colour was deeper. John Russell's account is consistent with this: He said that the one brilliant light he saw (both UAPs would still have been very close to aligned at this point, in azimuth, from *Fig.7*, and in elevation, from *Fig.8*) looked "orange" and appeared to him to move a little to the right during his sighting (W) which is consistent with rotation of the aircraft to the left during the start of the turn.

The graph of *Fig.8* shows only a small reduction in the descent slope during the minute or so after 1415:30, no pronounced pitch-up that would coincide with the end of Kate's first sighting. But the slope of the aircraft is interpolated from height plots at approximately 1.56nmi intervals, and it's very possible that the curve smoothes out changes in the aircraft pitch during the 56 seconds and 300ft of descent between successive height reports at 1415:26 and 1416:22.

At first sight one aspect of Kate Russell's account is in conflict with this construction. Kate said[23] that when the nose dipped for the first time she looked and could see two lights through the front windscreen, one of which was "roughly where I was expecting the airport to be (over Alderney)".[24] But Capt Bowyer did not at any time see the UAPs over Alderney, rather they were

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[22] One would expect the angle to be if anything somewhat less than 20°, consistent with the well-known tendency of observers to overestimate visual angles.

[23] Telephone interview with David Clarke.

[24] The passenger seating positions in relation to the high instrument panel, and the slight nose-up cruise attitude of the Trislander, mean that the horizon ahead would not be visible until the angle of descent reached a few degrees.

some degrees further to the west. *Fig 7* predicts that when first seen the bearing to UAP#1 would have passed directly across the centre of Guernsey. From the time of Kate's first sighting the triangulated LOS lies over the west side of Guernsey, between about 10° and 15° to the right (W) of the bearing to Alderney.

This is a puzzling discrepancy, but one which (one feels) must have a simple explanation. Indeed a reasonable explanation does exist as follows:

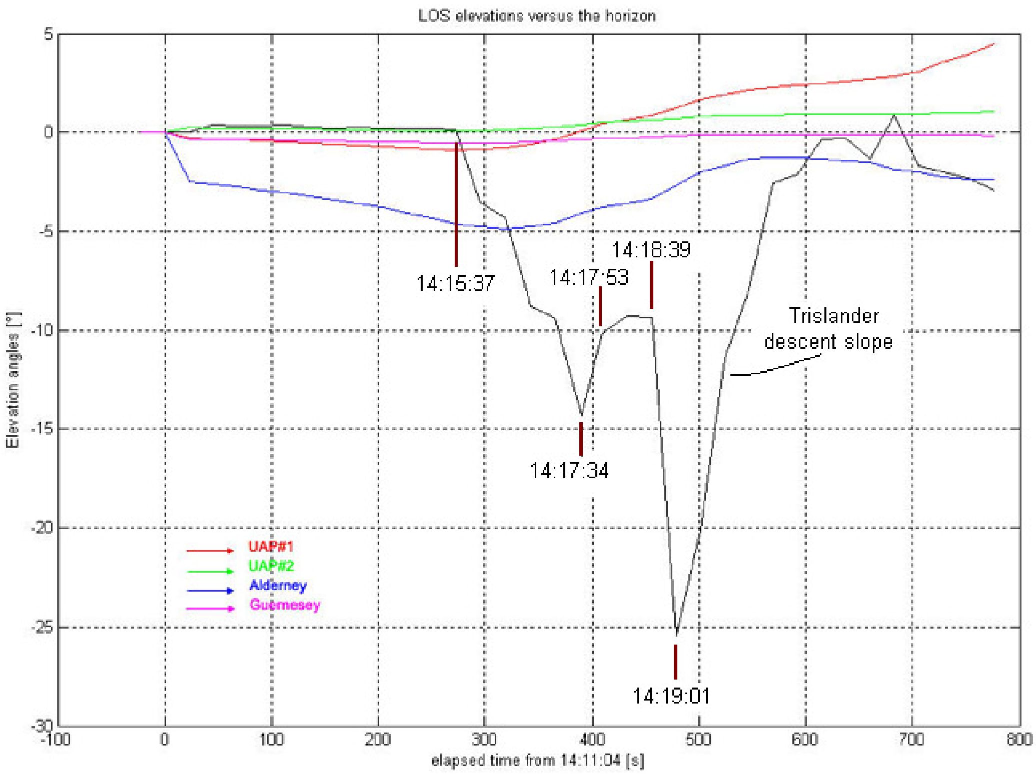

Fig. 8. Horizon elevations of lines of sight to both UAPs and to the islands of Guernsey and Alderney, plotted against the descent slope (black curve) of the Trislander as a function of time

Just after the start of descent at 1416 Alderney was about 13nmi away and would appear about 10° across at a small depression angle of a few degrees. The larger island of Guernsey was about 35nmi away, nearer the horizon, and would appear about 8° across. Capt Bowyer states that both Alderney and Guernsey were visible before descending to the haze although visibility was somewhat poor.

Kate was "expecting" Alderney to be almost dead ahead of their nominal 207° course on R41, so when the nose dipped at about 1416 and a hazy island of about the right angular size rose into view she could reasonably believe it to be Alderney. But in fact the radar plot shows that the aircraft's heading had departed from 207° shortly after the second object was seen when passing ORTAC (see *Section 3, Fig.6*), and at 1416 was about 212°. The island most nearly ahead of the aircraft would be Guernsey.

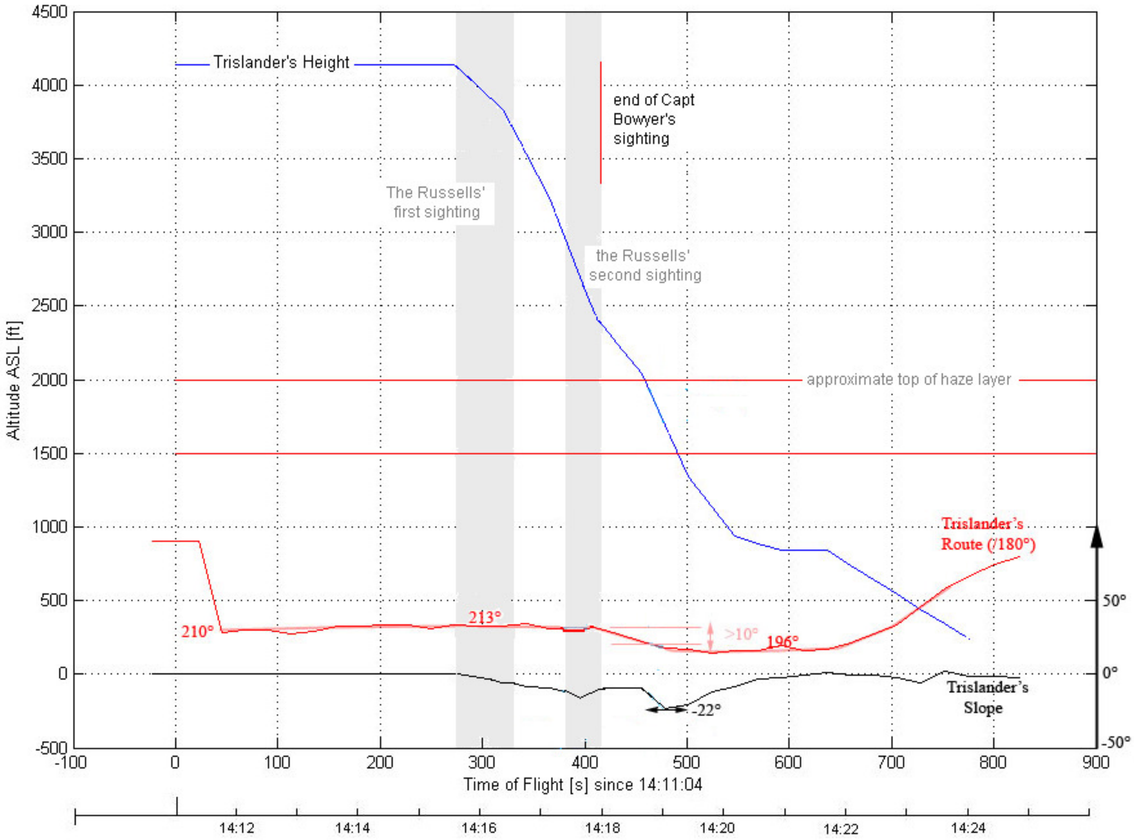

Fig. 9. Altitude, heading and descent slope of the Trislander plotted as a function of time

Moreover, this effect would be increased by the wind correction or "crabbing" angle of the aircraft. This is the difference between the instant heading and the average course of the aircraft due to the need to compensate for the wind vector. Unless the wind is dead ahead, dead astern or zero knots, there will always be a some rotation of the aircraft coordinate axis relative to the course flown.

The Indicated Air Speed (IAS) shown in Capt Bowyer's CAA report is 130kts. Taking 130kts IAS as equivalent to about 140kts TAS[25] and plugging in the forecast 8 kt SW wind (from the same report) only gives us about 1 deg correction.[26] But 8kts at over 4000ft does seem light compared to the weather reports and surrounding balloon ascents. The Met Office Form214 forecast, and Brest and Camborne noon ascents show 20, 19 and 23kts respectively at the flight level, from 230°, 236° and 220° respectively (see *Section 5*). Allowing 20-25kts from 220-230° gives between 2° and 4° of crab angle, and a ground speed around 116kts - which is close to the average 115kts we can measure on the radar plot for the pre-descent period 1405:42 - 1415:36.

Thus the aircraft axis could be rotated as far as about 216° azimuth at the time of Kate Russell's first sighting, in which case a LOS dropped from the aircraft centreline would run roughly across

[25] This is a standard correction proportional to altitude. It is necessary because the onboard airspeed indicator does not automatically recalibrate itself for variation in air pressure.

[26] These computations are traditionally performed by pilots using a hand-held calculating device known as an E6B . We have employed an on-line digital emulation of an E6B available at http://www.csgnetwork.com/e6bcalc.html

the middle of Guernsey.[27]

Being more distant Guernsey would of course be at a smaller negative elevation than Alderney, i.e. would be closer to the horizon, and would be the first to appear as the nose dipped. Kate's view past Capt Bowyer (in the left cockpit seat) from her passenger seat three rows back could well have been restricted in the direction of Alderney - slightly lower and to the left of the flight track. It is clear from *Fig.8* that the smoothed-over difference in pitch angle that is sufficient to reveal and conceal the UAPs for Kate's first sighting cannot be large, and is very unlikely to exceed 5°. The difference in elevation of Alderney and Guernsey at this time is about 4°. So if a UAP which "appeared to be over the land (Alderney)" was really above Guernsey then Alderney cannot have been far above the bottom edge of the windscreen, as well as being displaced by almost 20° to the left of the field of view where it was most likely to be obscured by the pilot.

This first sighting, said Kate, lasted "a few minutes" until the nose came up again and obscured the UAPs and the island. It appears the duration was somewhat less than this. *Fig.8* permits room for only perhaps 90 seconds or so between the start of descent and Kate's second sighting, occurring shortly after 1417. By 1418 the plane was descending towards the top of the haze layer at about 2000ft and near-horizontal visibility reduced dramatically. Guernsey was now lost to view, and at the same time Capt Bowyer had reduced the slope of descent from about -14° to -9°, i.e., the nose came up about 5°, between about 1417:35 and 1418. At this time all parties lost visual contact with both UAPs. By the time the plane emerged through the haze at about 1419 on a steeper descent slope (25°) it had completed its turn of about 16° onto a course towards the E of Alderney for final approach and landing on Runway 26. At this time Alderney itself at a distance of only ~7.5nmi would be over 20° wide and filling the centre of the windscreen.

In short, it seems possible that Kate could have been unable to see both Guernsey and Alderney simultaneously at any time during this descent and could have mistaken one for the other, which would explain an otherwise puzzling contradiction.

The LOS elevation angles in *Fig 8* are computed for UAP heights of 2000ft ASL, the estimated altitude of the top of the haze layer. Capt. Bowyer's impression was that the UAPs were phenomena that finished up located in or near the top of the haze layer, somewhere between 2000 and 1500ft. It is interesting to note that by assuming this rough figure then the changing sighting geometry implied in the several sighting narratives seems for the most part internally consistent.

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[27] This possible difference between forecast and actual winds brings to mind the discrepant 1420Z landing time given in the flight log, at which time radar shows the Trislander still about 5nmi N of Alderney. We can measure the cruise speed for the pre-descent period 1405:42 - 1415:36 from the radar plot at about 115kts GS. But the logged times 1339-1420 give 41mins in total, tarmac to tarmac, which would equal about 119kts average GS over 81.2nmi linear distance, and since the true trip distance includes climb out, a small off-course westerly deviation, and slowing/manoeuvring for approach, a max cruise speed even *higher* than 119kts is implied. The difference between the logged trip time and the radar-measured trip time is about 8%, equivalent to about an extra 10kts adverse wind, adding which to the flight log's forecast 8kts brings us close to the ~20kts that we get from other weather data (the adverse wind vector would not be 100% of the wind velocity). It may not be a coincidence that a forecast landing time on the basis of 8kt winds would have been close to the logged (and erroneous) landing time.

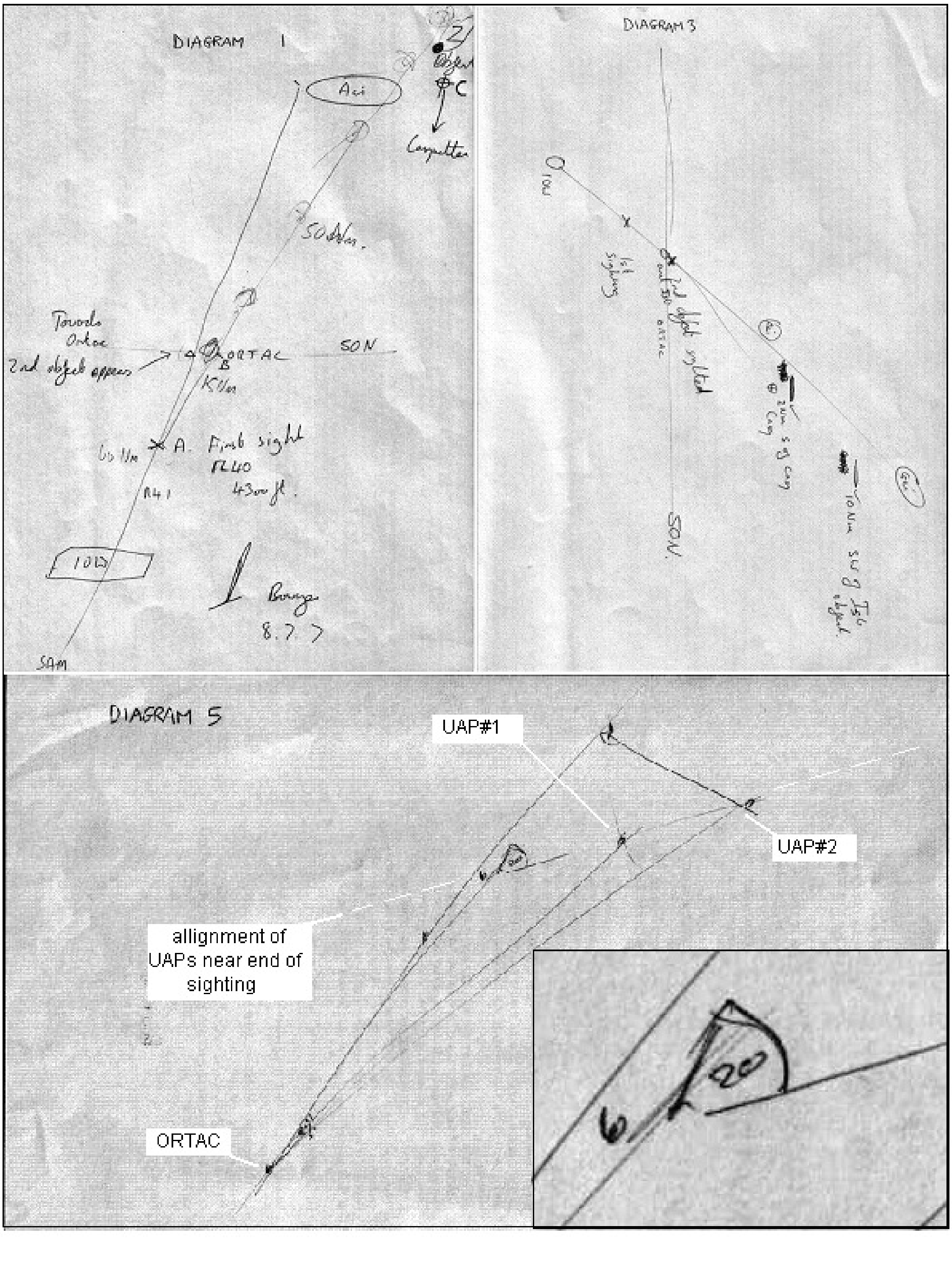

Fig. 10. sketches of the sighting geometry made by Capt Bowyer during interview (intended to be illustrative only). SAM = Southampton, IOW = Isle of Wight, ACI = Alderney Channel Islands, GCI = Guernsey Diagram 5 (bottom, with authors' annotations) shows changing lines of sight to both UAPs and 20° orientation of final LOS at point of turn (inset).

Initially UAP#1 was visible on or close to the sea horizon[28] on a LOS that runs across the island of Guernsey, over 50nmi away at the time and therefore also quite close to the horizon (about 69nmi away from 4200ft ASL). As the plane approached in level cruise, the LOS to #1 rotated a few degrees to the W, whilst at the same time the apparent size of the UAP increased, and the depression angle to the UAP grew a little steeper. This last effect was acknowledged by Capt. Bowyer as difficult to judge bearing in mind the curvature of the earth, but he estimated that at the point just before he began his descent, at about 1415, the depression angle had reached a maximum of approximately -2°. (At this time the relative elevation of UAP#1, if at 2000ft ASL at the triangulated position in *Fig 7*, would be about -1.5°.) The depression angle to the island of Guernsey, however, over 4000 ft below, had increased more rapidly[29] so that the UAP was now visible against the backdrop of the sea beyond. Thus the changing elevations were such that during the sighting UAP#1 was seen "against [both] the sea and the island" (#2 having meantime been observed some degrees to the right of #1 and appearing always above the open sea[30]).

Just as Capt. Bowyer acknowledged clearance to descend to 2000ft at 1415:43 he reported to Paul Kelly that the UAPs, which had grown larger, were now "very plain to see . . .without any binoculars". It was just after this that he started descent and Kate Russell saw the UAPs through the front windscreen against the backdrop of the sea, even apparently "coming out of the sea" as it appeared to her. We have seen that they would have appeared above the bottom edge of the windscreen by only a few degrees. Guernsey, a few degrees below UAP#1, would have followed them, rising into view just enough to be mistakenly identified as the aircraft's destination (Alderney), before the pitch angle reduced once more after a few tens of seconds and the objects were briefly lost to Kate's view. At this time the plane was still perhaps 1500ft or so above the haze layer.

The UAPs were still being watched by Capt. Bowyer who reported to Jersey Zone at 1417:14. that the UAPs seemed to be below him at about 2000-1500ft ASL, i.e., close to the top of the haze layer. He noticed that as the descent continued the relative elevation of the UAPs began to rise again, i.e. the depression angle diminished, tending back towards the horizontal, whilst at the same time the vertical separation of the two lights also decreased.[31]

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28 Capt. Bowyer points out that the thin haze layer and the sea surface are effectively merged at the distant horizon.

29 To some -6° below a horizontal plane tangent to the track of the aircraft, which has a radius of curvature = earth-radius + 4200ft, and almost 5° below the geometrical earth horizon.

30 Is it possible that UAP #2 may have been obscured in the haze prior to sighting at 1412? This is Capt. Bowyer's opinion. He points out that #2 appeared to be in the lee of Guernsey, where SW winds may have "pushed up" the haze layer. Other explanations, such as mutual occultation or mirage/reflection effects etc, are of course possible.

31 The vertical separation of the two UAPs reportedly reduced by approximately ½ between the time #2 first appeared at ~1413 and the final disappearance at ~1418. The initial vertical separation as drawn by Capt Bowyer (*Fig 4*) is about 1/3 of the angular width of UAP #1, which, interpolating between the terminal values of 0.5° and 1.25°, gives ~0.9/3 = 0.3° (very close to the 0.4° we get for two objects both at 2000ft positioned as in *Fig.7*). The final vertical separation ought therefore to be about 0.15°. The final vertical separation was estimated as 6 - 8 times the vertical depth of UAP#2. The mean of the aspect ratios of the UAPs depicted in Capt Bowyer's two larger scale drawings (*Figs 2 & 3*), about 13:1, leads to a value for the final vertical depth of UAP#2 equal to ~0.65/13 = 0.05°, and 6 x 0.05 = 0.3°, or the *same* as the initial separation. So it appears we do have here a factor 2 inconsistency between one minor element of the report and the geometry of *Fig.7*. But Capt Bowyer did add the specific disclaimer that his judgment of 6 - 8 times the vertical depth of UAP#2 was probably unreliable owing to the deceptive lateral offset between the two UAPs. In terms of typical witness estimates of quantities this is an extremely small error and would scarcely be notable at all were it not for the exceptional consistency of other linear and angular ratios.

At about this same time, with the plane about 1100ft above the haze, the nose of the plane dipped a second time and Kate Russell was afforded another view of the objects. The azimuth separation between UAP#1 and #2 was still near zero, and both objects appeared very close together. At this time John Russell was able to lean across and obtain a brief view. He was only able to discern one brilliant “lozenge” of light, appearing to him as “orange” in colour, drifting a little to the right as the aircraft turned towards Alderney.

But Capt Bowyer was able to observe that the lines of sight to the two UAPs continued to cross, until at about 1418, when nearing the top of the haze, #2 had moved a couple of degrees to the left of #1. And they no longer appeared to be below his altitude. They now appeared to be almost level with the plane. Almost immediately after entering the haze they were finally lost to view.

This geometry is not inconsistent with the report by the Blue Islands Jetstream pilot, Capt Patterson, who observed a large “oblong” or “oval” object of hazy outline, having a yellow colour, at the bearing and range of the UAP#1 position triangulated in *Fig.16*. Moreover Capt Patterson reported at 1415:08 that the apparent altitude of the UAP was possibly 2000ft below him, i.e., at about 2000ft ASL.[32]

It is interesting to note that the radio transcript proves these altitude estimates to be independent of one another. Capt Patterson had been listening to the exchanges between Capt Bowyer and Channel Islands Zone, but Bowyer had earlier said that he thought the object was at his level (FL40). Kelly asked him to confirm this at 1412:36, which he did. That was the last height reference before Patterson’s report at 1415:08. Similarly, when Bowyer reports to Zone at 1417:14, "Low to me now, er, I'd say 2000 feet, 1500," he doesn’t know about Patterson’s report, which was made on a different frequency to Jersey Approach Control. At this stage it appears that Zone Controller Paul Kelly doesn't know about it either, and he certainly does not make any mention of it to Bowyer.

A final point of interest is that Capt Patterson does *not* initially see anything when he is passing Guernsey at about FL70 - 65. At this time he confirms to Kelly that he has overheard the transmissions from Capt Bowyer and knows what he is supposed to look for, but replies there is "nothing at all" in the area.

This perhaps argues against the suggestion that Patterson, primed by hearing the report, is over-sensitised to the possibility of seeing something unusual and is thus compromised as a reliable witness. He is not reporting something just because he's asked to. He looked for over minute before saying he could see "nothing in that position at all, I can't see anything" at 1413:13.

But then a couple of minutes later when down to about FL40 he does see an object "answering the description" in the correct area, and he watches that on and off (in between flight duties) for about a minute, reporting it to Approach Control. He apparently took this seriously enough to put it in writing in a report the next day under the heading "Unidentified Flying Object NNW of

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[32] Note that the radar plot allows us to see that Capt Patterson’s line of sight to his indicated UAP position 20nmi away would fall aft by some 10° during his sighting, and the relative height would change by ~1300ft or about 0.5° of elevation. His judgments of geographical location (just NW or W of Alderney) and altitude are therefore themselves tested by triangulated lines of sight and a degree of parallax.

Alderney", repeating that he saw an object "fitting the description" and signing his name[33] to it.

Obviously it is true that Capt Patterson knew roughly where to look and knew the description Capt Bowyer gave over the radio - that, after all, is how he is able to say that his object "answers the description". But there is no evidence of undue influence. Indeed there is proof of independence in respect of a significant quantitative judgment, and Patterson's actions in observing and reporting imply caution and deliberation on his part.

This object appeared ill-defined and little more than an oblong hazy patch. But the observer noted that he had not seen anything like it before on this route, or indeed on any other. It was a significant angular size and its estimated Trislander-yellow brightness of colour (taking account of haze extinction) is noteworthy. Pressed for an explanation he suggested that a large balloon or airship, possibly military, might resemble what he saw, or perhaps an unusually sunlit guano-covered island near Alderney. (It was established by questioning that the island of Burhou NW of Alderney was simultaneously visible and the object was estimated to be somewhat further west.) But it was "probably not at sea level and not attached to the land". His best guess is that it was some sort of atmospheric phenomenon.

The physical size was bracketed with two estimates: Possibly 4 or 5 times the 50ft length of a Trislander fuselage (200-250ft, 61-76m) but 0.5 NM (~900m) maximum, estimated by comparison with the nearby island of Alderney. The latter is a factor 2 larger than the size indicated by Capt Bowyer's angular estimate, but the observer does say that this is a "maximum". The mean of his two disparate estimates is ~485m.[34] It is interesting to compare this with values earlier derived from Capt Bowyer's sighting geometry: Approximately, initial angular size of 0.5° @ 35NM = 560m; terminal angular size of 1.25° @ 12NM = 460m; mean, 510m.

On the whole we have to say the reports show a notable degree consistency on most indicators if interpreted as observations of some large object or feature at the triangulated location. Of course one of many questions arising is this: If Jetstream (like the FlyBe 146 in a similar position a little later) could not see anything at 1413 from above FL65 and reciprocal to the Trislander's LOS, why not? We discuss this and many other issues in relation to the hypotheses introduced in *Section 6* and the conclusions offered in *Section 7*.

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33 Blacked out of course in the copy released by MoD (reproduced in *Appendix A*).

34 Capt Patterson's impression of a ~70m physical length, based on mental comparison with a *Trislander* at the range of Alderney, *may* have been influenced by an underestimated range. The CAA report records his estimated range as 10nmi when Alderney was more like 17nmi, so correcting by a factor 1.7 would give us about 115 metres. (It is reasonable to infer that this was a visual range estimate reported by Capt Patterson since any figure introduced by Channel Zone controller Paul Kelly could only have been based on the radar plot and ought not to have been in error). On the other hand, in making the direct comparison with Alderney, how accurate was Capt Patterson's judgment of the true cross-sectional width of the island from this perspective? Perspective foreshortening of the obliquely oriented island would present an image whose angular width, if taken for the known map length of the island, would tend if anything to act as an inflated yardstick. This could lead to an *over*estimate of physical length, meaning that we should possibly *reduce* somewhat the estimated "maximum" of 900m. But if we assume that these unevaluable sources of error, of opposite sign, simply cancel out, then we find that the mean of his two stated estimates is a bit less than 500m, of the same order as the size implied by Capt Bowyer's angular estimates.

4) Radar Observations

a) military radar

There is no UK air defence radar coverage of the Channel Islands area at relevant altitude. MoD say they have no information on any possible radar contacts. The Channel Islands Air Traffic Control Zone lies within the French air defence zone. A French long-range Centaure air defence radar with coverage of the area is located close by at Maupertus near La Hague on the Cotentin peninsula.

An early inquiry to the French authorities eventually produced a negative response. CCOA (Centre de Conduite des Opérations Aériennes) informed us[35] that a reconstruction of all aerial movements in the region from the radar network log revealed no unidentified phenomenon or aircraft in the time frame of interest (1409-1418Z). However they also informed us that the radar data would be routinely dumped after only a few hundred hours. At this time CCOA stated that they had not yet been in receipt of an official request for radar data by GEIPAN.[36]

We pursued inquiries through GEIPAN but they were unresponsive. We then approached a French researcher associated with NARCAP[37] who was also connected with individuals working for GEIPAN's "college of experts". We learned informally *via* this route that GEIPAN had been independently advised by French air defence sources that no radar data were extant, having been destroyed after eight weeks.

b) Air Traffic Control radar

As mentioned in *Section 3* we had obtained useful composite screenshots of the Channel Islands Control Zone ATC radar picture produced by the ELVIRA software from radar files in ASTERIX format (a European standard format for radar data management). We were also provided by Jersey ATC with a complete 24-hour ELVIRA radar playback and original data files in RDIF format for a period of several hours containing the sighting period. However for various reasons[38] the following discussion is limited to the information contained in composite

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[35] Email to Jean-Francois Baure, 07.06.07: "Suite à votre demande j'ai fait faire les restitutions radar de tous les mouvements aériens détectés dans la région que vous m'aviez décrite et pendant le créneau horaire suivant: 23/04/2007 entre 14h09 loc et 14h 18 loc.heure anglaise. Aucun phénomène (hormi les aéronefs sous contrôle civil ou militaire) n'a été detecté par notre réseau de radars."

[36] GEIPAN (groupe d'études et d'informations sur les phénomènes aérospatiaux non identifiés) is the official UAP investigation group of CNES (France's National Centre for Space Studies). http://www.cnes.fr/web/5038-geipan.php),

[37] National Aviation Reporting Centre on Unidentified Aerial Phenomena, a US air-safety oriented organisation. Co-author Martin Shough is a Research Associate for NARCAP. http://www.narcap.org

[38] For commercial licensing reasons it transpired that Jersey ATC were unable to share the software for viewing the complete files. We had mathematical and computing expertise in our team, but the task of writing a viewer to visualise the data was a huge and impracticable one. Costly commercial software required prohibitive machine specifications. Air traffic management experts at the Dutch National Aerospace Laboratory (NLR) in Amsterdam were among many who provided helpful advice and offered to visualise the data for us but only under a commercial contract. However at an early stage we had discussion with GEIPAN who indicated a possible interest owing to the location of the incident. Dr. Clarke met in Italy with GEIPAN's director Jacques Patenet offering an exchange of information and specifically requesting CNES expertise to assist with accessing the radar data files provided by

screenshot format. We discuss later the extent to which this limitation affects present conclusions.

Controlled airspace extends from the surface to 18,000ft throughout the Channel Islands Zone. It is managed from the Air Traffic Control centre at Jersey States Airport, where the radar picture is assembled from two radar sources. The SSR (Secondary Surveillance Radar) antenna sited on Jersey provides signals from transponder-equipped air traffic[39], whilst primary echoes from non-transponder traffic and other radar targets are provided by a feed from a separate PSR (Primary Surveillance Radar) antenna sited on the island of Guernsey.

In addition to the SSR plots of transponder-carrying aircraft the ATC radar showed a large number of primary contacts (echoes of radar pulses from reflective objects or surfaces) detected by the Guernsey radar head. Most of these contacts were impossible to positively identify from the plot-extracted synthetic display provided by ELIVIRA (see *Fig. 11*). It is to be expected that some are due to sea birds, surface ships and other commonplace reflectors, in combination with anomalous propagation as originally suspected by Controller Paul Kelly.

On first contact with Jersey, Capt Bowyer simply asked Kelly if radar showed any traffic directly ahead of him in his 12 o'clock. Kelly replied in the negative. However he did advise that there was a primary target showing at 11 o'clock 4 miles from the aircraft. At 1411:11 Kelly advised Bowyer that there was a primary target now 10 o'clock 3 miles from the aircraft, but suggested it might be an anomalous propagation echo. A few primary contacts are visible close to the flight track around 10-15nmi NNE of ORTAC on the radar map in *Fig.7*. The Trislander appears to leave these behind. They appear unrelated to the object observed visually.

Not until 1414:23 did Kelly reply to another query from Capt Bowyer to the effect that he now had a primary target - "a single blob" - about 8 miles W of Alderney in the vicinity of the Casquets. Bowyer commented that this could fit the position of one of the UAPs. This echo was still there at 1415 when Kelly asked the FlyBe 146 to look for a visual on a primary target, below them about 1 mile on their right, again "in the vicinity of the Casquets". The FlyBe was unable to see anything.

Jersey ATC. When we encountered difficulties finding accessible software we reverted to GEIPAN, but we now learned (*via* the third party already mentioned) that GEIPAN were unable to offer cooperation, moreover that they had in fact made an independent approach to Jersey ATC for the same data files, and that the ATC specialist working with GEIPAN would be unable to share the radar visualisation software with us. Given GEIPAN's official access to facilities and expertise we concluded that duplication of effort would be a waste of our limited resources. We decided to focus on other aspects of the investigation and await the completion of GEIPAN's detailed study of the radar files.

[39] The aircraft's onboard radar transponder beacon sends automatic replies to interrogations received from the ground radar. Coded replies identify the aircraft on the radar screen alongside altitudes derived from the aircraft's pressure altimeter

In his CAA report Paul Kelly described this echo as "anaprop possibly associated with one of the objects". He confirmed to us later[40] and independently to Capt Bowyer that it was unstable or "ragged", and that in his opinion it was probably not a solid target. However this echo position - about 1 mile on the right of FlyBe at about 1415 - would be close to the 1415 position of one quite prominent slow target plotted moving north of Guernsey, shown as Track B in *Fig 12*. Whilst this could possibly be described as "ragged"[41] it appears to be a fairly definite track rather than sporadic anomalous propagation.

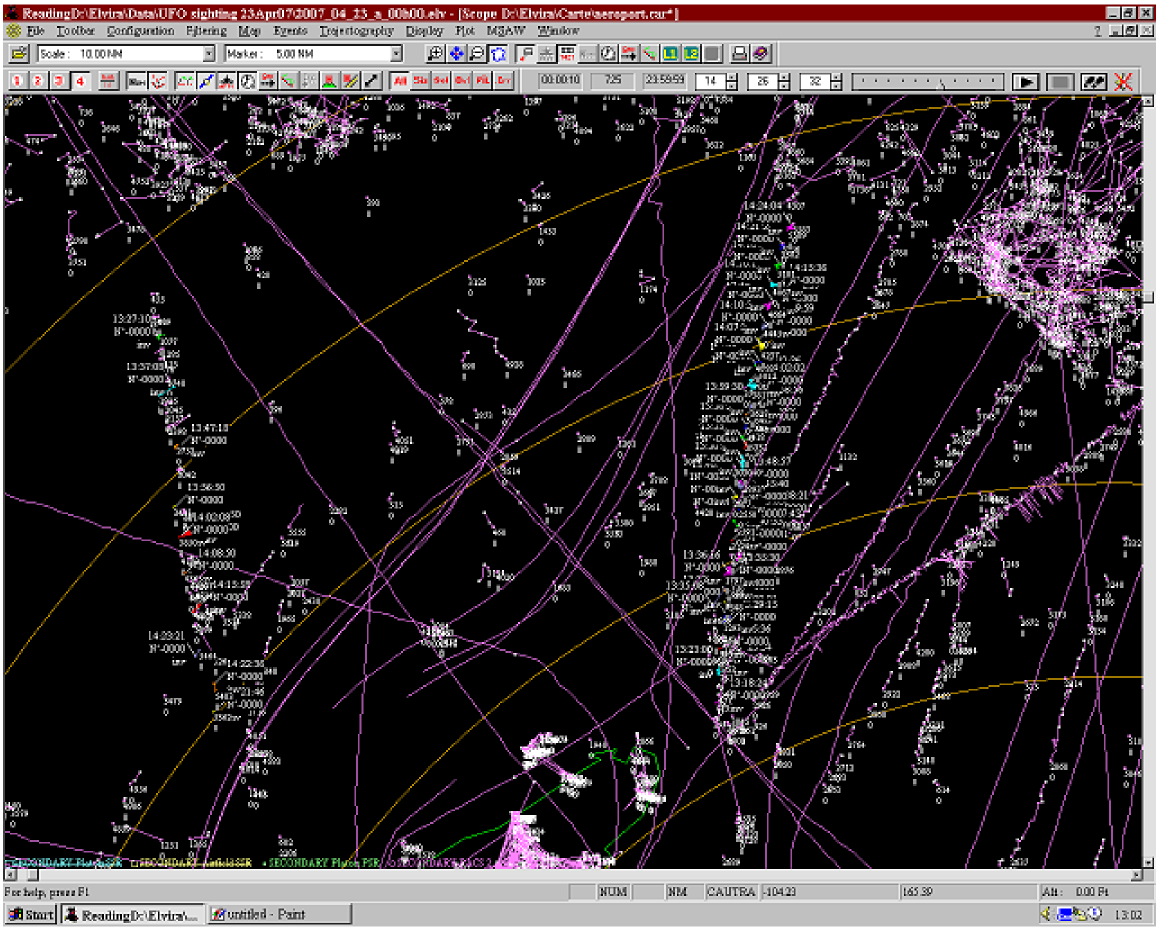

Fig.11 Composite screenshot of ATC radar picture showing primary echoes in the sighting area.

[40] Telephone conversation with Jean-Francois Baure.

[41] The variety of screen colours used for successive plots in *Fig 11* indicates this. The overall track seen here is not produced automatically by plot-extraction software; rather, Jersey radar engineers have made a manual selection of an apparently connected sequence of short track segments. The software has allocated colours at random for each new segment. An unbroken track would retain the same colour, so we can see that this track has many missing data points.

It was suspected early on that this and another track (Track A, *Fig.12*), similar but moving southbound at a few knots, could be surface ships on routes between the Channel Islands and the south coast ports of England. Capt Bowyer noted:

> There are a number of spurious primary returns but there are also however two very definite tracks each lasting around an hour and then disappearing, one, the closest travelling north at about 10 kts, the second travelling south at a similar speed five miles further west. They would appear to be in the correct position from my point of view.[42]
>
> It is possible that they may be ships as the primary return is very sound and speed conducive with a ship, however, no large vessels travel on the west side of Guernsey and the East side plot does not coincide with any regular service out of Guernsey as far as I can ascertain.[43]

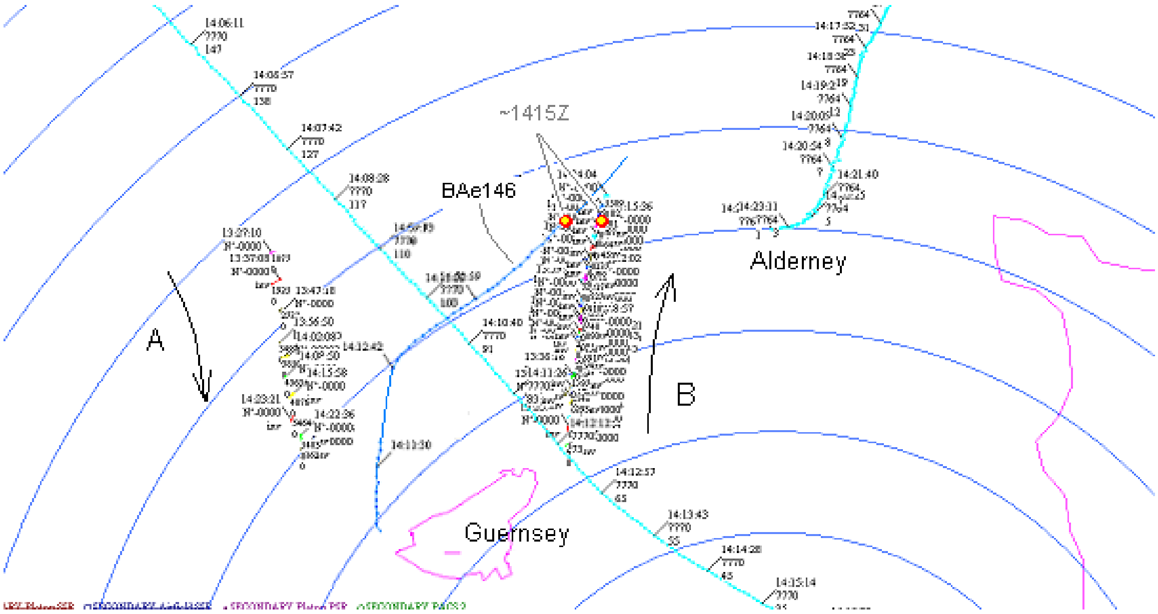

Fig. 12 Radar plots of two slow-moving primary echo tracks (A & B), indicating simultaneous positions of track B and FlyBe BAe146 at 1415Z

Timetables of ferry routes between St. Malo, the Channel Islands, and the south coast ports of England were studied and inquiries were made of the St. Malo Harbourmaster.[44] Journey times are subject to change due to weather and tidal variation and it was not possible to locate records of the day's exact sailing times. But evidence suggests that one echo (Track B in *Fig.12*) could be a northbound Brittany Ferries vessel[45] scheduled to leave St Malo at 09:45Z and arriving in Portsmouth at 19:30Z, reaching the vicinity of Alderney at approximately 14:30Z. Inquiries to

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42 In fact the line of sight to the westernmost track (A) would be several degrees beyond the western limit of the bearing to the UAPs which is delimited by the Casquets Lighthouse. Track B could quite close to the location of UAP #1 as triangulated by the lines of sight (see *Section 3*)

43 Email from Capt Bowyer to Dave Clarke, 24.06.07

44 Email from Bruno Lassus, Le Commandant de Port, St.Malo port authority, to J-F.Baure, 17.07.2007. A second vessel, the NOLA, departing St Malo for Amsterdam the previous evening, may also have been in the area.

45 MV BRETAGNE, see http://www.brittany-ferries.co.uk/index.cfm?articleid=149

the Guernsey Harbourmaster disclosed[46] that all regular sailings would traverse the Little Russel channel on the east side of Guernsey delimited by the Little Russel (or Roustel) Lighthouse located off the northwest point of the island of Herm. If Track B is extrapolated southward it passes approximately through this channel (see *Fig.13*).

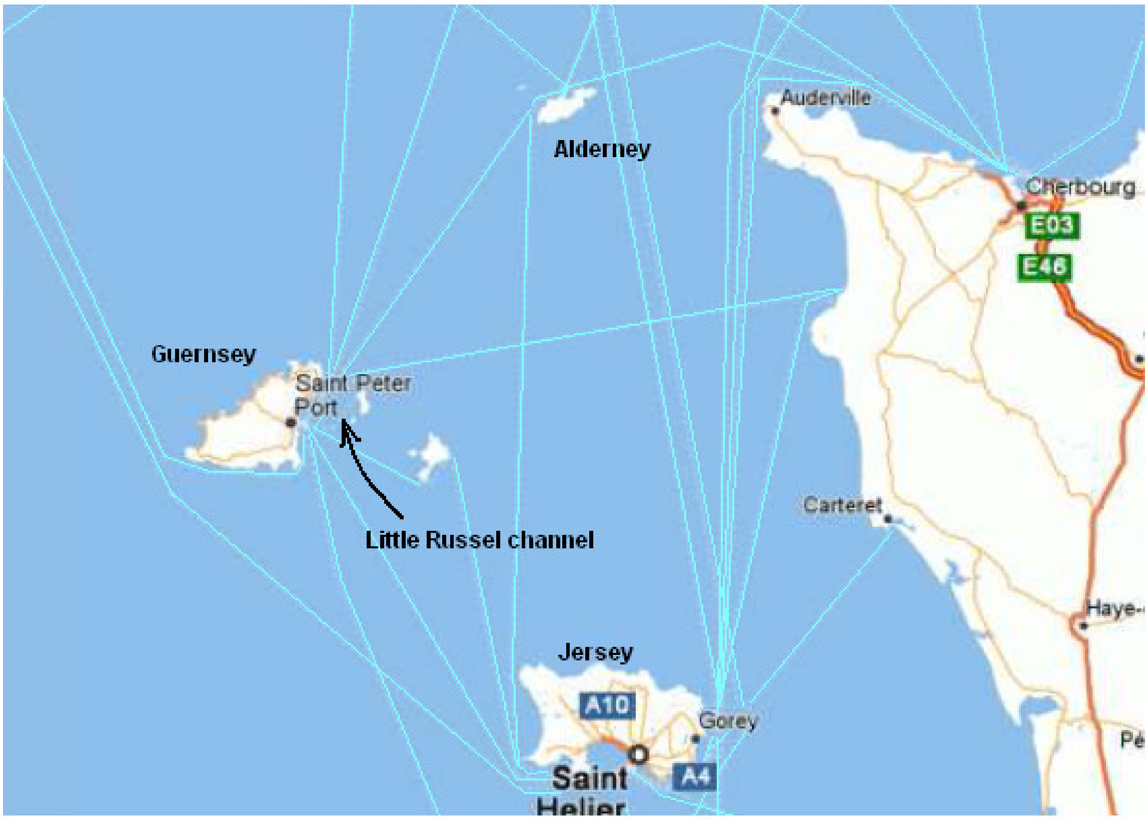

Fig.13 Shipping navigation routes in the Channel Islands (adapted from Multimap)

The radar track passing to the W of Guernsey (Track A in *Fig.12*) is also close to a navigation route heading around the SW tip of Guernsey (*via* the Hanois Light and then NNW) and another route from St Helier, Jersey (*Fig.13*). But the only vessel of any size in this vicinity on that day, according to the Guernsey Harbourmaster's records, was a vessel called the *Agility* which left Guernsey "at 11:04 Alpha" (a military time zone equivalent to CET or BST, i.e. GMT+1 = 10:04Z), or four hours before the start of the sighting. This is not only the wrong time frame for the western track we see on the radar; the *Agility* was outward bound for Milford Haven, Wales, whilst the radar track is headed south.[47]

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[46] Letter from AJB Pattimore, Deputy Harbourmaster, Guernsey Harbour Authority, to Paul Fuller, 14 Aug 2007.
[47] Note that the projection of this track on the sea surface 30-40nmi away from the Jersey radar antenna would be approaching twice the normal horizon distance from the radar, and it can be shown that even in radio trapping conditions (more severe than the moderately super-refractive conditions for which there is evidence) it would lie entirely in the radar-shadow of the Island of Guernsey. These primary contacts are fed in to the radar picture from the antenna sited on the island of Guernsey .

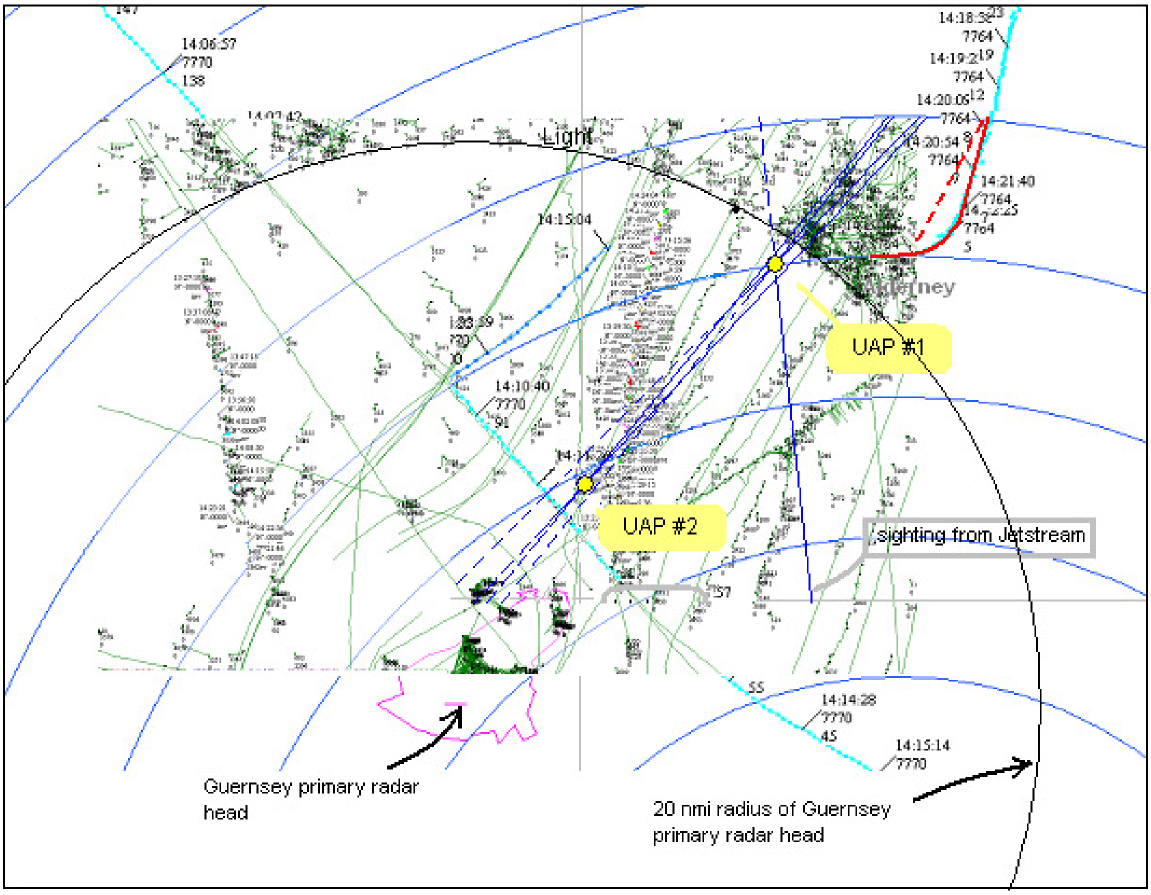

Fig.14 An ELVIRA screenshot of primary plots in the Guernsey area merged with the base radar map showing triangulated visual UAP positions (from Section 3. Fig.7). Note low target density inside 20nmi radius of the Guernsey antenna.

So initial inquiries fell short of proving conclusively that either of these targets was a ship, but found a reasonable probability in at least one case. If the Guernsey Harbourmaster's records are complete then the other target remains unidentified, although an unrecorded smaller ship is a possibility.[48] We sought the opinion of Jersey radar engineers. They were "99% certain" that both of these tracks were ships on shipping lanes that were "clearly visible on . . . playback of Guernsey PSR data".[49] No obvious UAP echoes could be identified and specifically there appear to be no interesting plots corresponding to the UAP positions triangulated in *Fig.7*. However this is inconclusive.

48 Trislander passenger Kate Russell observed a "little fishing boat" ahead of the plane in the direction of the UAPs (see *Section 3* & *Appendix B).* Coastal vessels, small cargo ships, ferries and the like would not necessarily be governed by the mandatory traffic separation rules. There might also be unregistered rogue vessels operating on designated routes. A Nov 2003 Press Release from the marine insurance group *North of England P&I* stated: "Rule 10 on the conduct of vessels in traffic-separation schemes is one of the most frequently misunderstood sections of the IMO's 1972 International Regulations for Prevention of Collisions at Sea,' . . . 'Radio logs at, say, Dover in England or Ushant in France provide clear evidence of the problems that arise, with rogue vessels being regularly reported,' says Dr Anderson. 'Apart from increasing the risk of collisions, masters and owners of contravening vessels can face criminal action, heavy fines and costly delays.'"

49 Email from Simon Langlois to David Clarke 26.09.07

As Paul Kelly initially pointed out in his CAA report, and as was also acknowledged in the MoD response (*Appendix A*), echoes from stationary reflectors showing small or zero pulse-to-pulse phase difference could have been entirely eliminated by the moving target indicator (MTI) which was operating on the radar. The impression of Capt Bowyer, supported by the consistent triangulation of lines of sight developed in *Section 3*, was that the visual UAPs appeared to be either stationary or very slow moving.

Examination of *Fig. 11* reveals, aside from skin paints of known transponder traffic (purple curves), numerous other primary echoes in the area which were evidently not suppressed by MTI. Some tracks appear which may be VFR light aircraft operating at low altitude or possibly small boats, but there are many isolated plots and short, erratic tracks.

The nature of this clutter background is uncertain. Moving targets such as birds and even sea waves are examples of reflectors that might get through a broad MTI gate. In Simon Langlois' opinion most of the echoes are very unlikely to be due to birds because of range from the antenna, and unlikely to be sea return because of small wave heights in the prevailing weather conditions. However we found (*Section 5*) evidence of moderate radar super-refractivity which could have contributed to increased transient clutter from weak surface echo sources. We were advised by Simon Langlois that although the range-azimuth gate on the Jersey MTI filter was set at maximum (setting #3), for maximum suppression of clutter and irrelevant slow targets, the Guernsey radar is customarily operated with MTI rejection at a lower setting and therefore picks up a larger number of primary echoes. The vast majority of the non-aircraft targets appearing in *Figs 11 & 14* were detected by the Guernsey antenna.

It will be seen from *Fig.14* that many of these echoes have been suppressed within a 20nmi radius of the Guernsey antenna. This was done by Jersey ATC radar engineers at the request of Capt Bowyer in order to clarify the two tracks (A and B in *Fig 12*) now suspected to be ships. Clearly the density of transient clutter echoes within this radius is greater than shown, and conceivably there could be traces of slow-moving primary targets near the triangulated UAP locations which are suppressed in this view. Even outwith this 20nmi radius it is possible that dense knots of tracks (e.g., at the top right, near Alderney) could obscure echo from a slow-moving primary target. Perhaps the triangulation contains sources of error?

Clearly a complete analysis of all primary plots is required, for which we await the result of the GEIPAN analysis. But whilst granting the limitations of our study, we feel it advisable to caution that there may be no conclusive test for separating anomalous signal out of the noise background. We were informed by ATC radar engineer Simon Langlois[50] that the raw primary echo data is irrecoverably processed and digitised at the radar heads before being fed to the radar control room in the form of plot-extracted symbols.[51] Thus even if slow-moving radar-reflective UAPs in

[50] *Ibid.*

[51] This is a common engineering solution to the problem of bandwidth. A plot extractor (sometimes called "target evaluator" in the US; related terms include Automated Detection and Tracking [ADT] and track-while-scan) uses predictive software to associate tracks to targets and smooth the update rate. It produces a synthetic visual display which has greater clarity, track continuity and brightness than the "blips" updated only once per scan on a traditional PPI. It is also easy to insert alphanumeric target information in real time into the video and so the burdens on the operator are greatly eased. Moreover the information in the raw radar pulse forms is bandwidth-hungry, requiring special cabling between antenna and display, which is not always practicable. So if the plot digitisation is done at the

the area did return primary echoes whose velocity exceeded the MTI rejection threshold (perhaps only transiently)[52], the type of echo-diagnostic scope presentation cues traditionally available to primary analogue radar operators are permanently lost. It may remain impossible to confidently distinguish a significant plot from the background of insignificant clutter plots.

c) Jersey weather radar

The Jersey weather radar was of interest for two reasons. Unlike the ATC radar data, which is specially processed to remove non-aircraft targets, weather radars collect essentially unprocessed raw radar echo[53]. This enhanced the possibility of finding echo correlating with any stationary radar-reflective phenomena. Additionally, the weather radar images could contain information on likely radar propagation conditions at the time (see *Appendix D)* . We hoped that this information might help to calibrate conclusions reached about the temperature and humidity profiles of the atmosphere from indirect meteorological evidence. This in turn might help to improve our confidence in the likely optical refractive index values (see *Section 5, Meteorological Conditions in Sighting Area*).

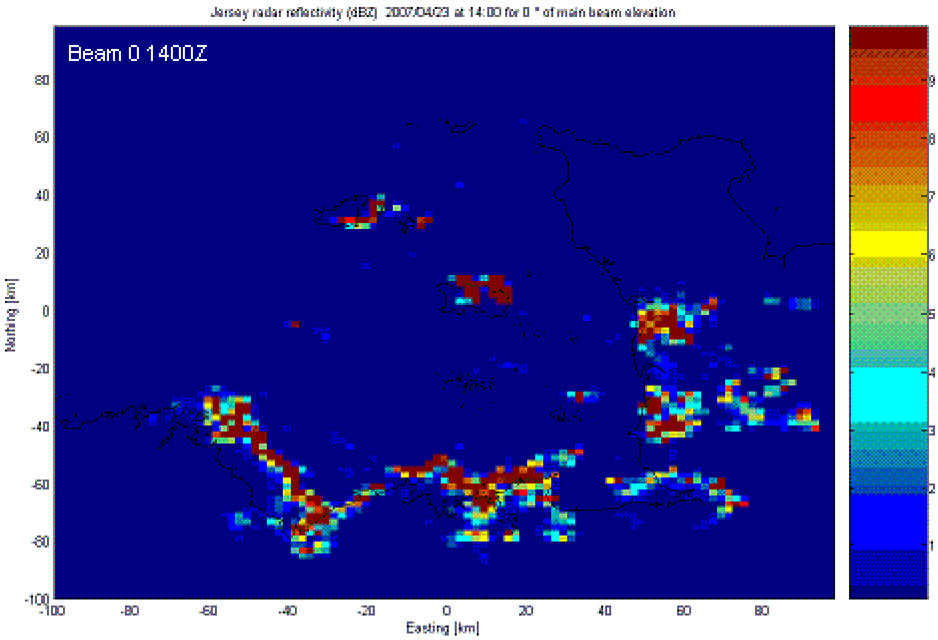

Fig.15 C-band weather radar, beam 0 (0.5°), 1400Z

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radar head the bandwidth required for data transmission between the antenna and the display can be reduced by a factor of perhaps 10,000 from Mhz down to a few hundred Hz, allowing the use of ordinary telephone landlines or radio channels so that antenna and display can if necessary be separated by the ocean, as in this case.

52 Glint echoes from essentially stationary targets might also lead to detection. Radar echo is generally the sum of many different wavefronts with different phases, and where an asymmetrical object or an object with a complex structure undergoes rotation without bulk translation the phase centroid of the echo might move outside the geometrical volume of the reflector. If this displacement is sufficiently large and/or rapid it might defeat the MTI filter.

53 Some limited signal processing may be done and this was investigated by enquiries to Jersey Met Office and from internal evidence (see *Appendix*). But it is in any case limited to possible subtraction of permanent ground clutter by means of a clutter map and/or insertion of data from higher-level cuts into these areas. This does not affect coverage of targets in areas free from permanent ground clutter, i.e., over the open sea.

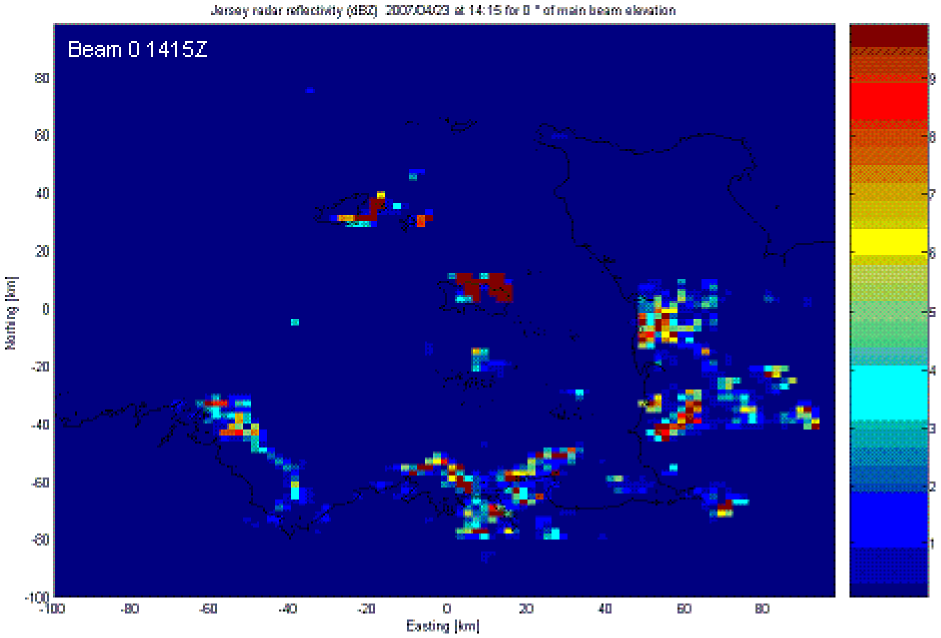

Fig.16 C-band weather radar, beam 0 (0.5°), 1415Z

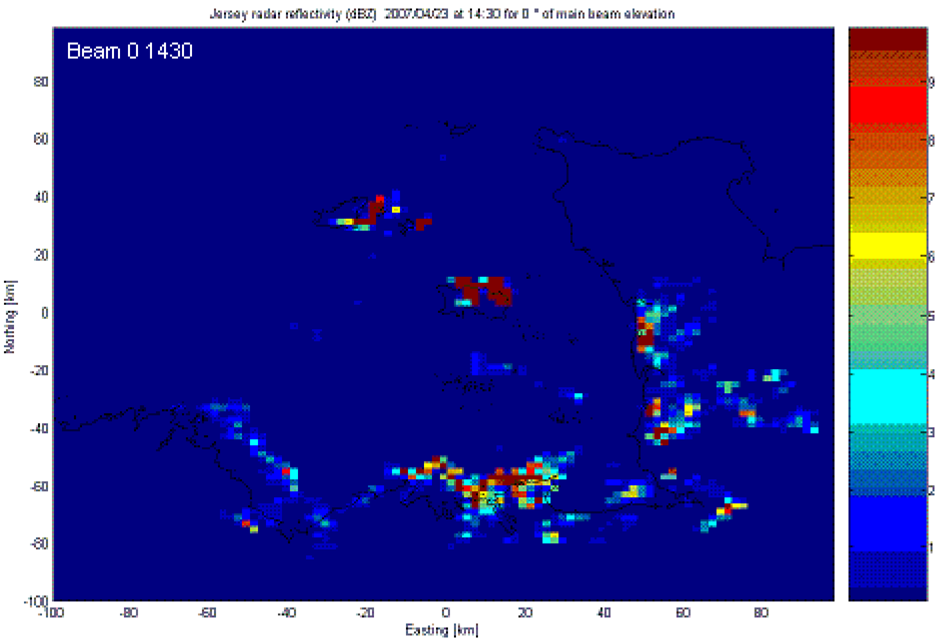

Fig.17 C-band weather radar, beam 0 (0.5°), 1430Z

Operated by Jersey Meteorological Office and located in the SW of the island near the airport, this is a C-band weather radar employing a 5 minute scan algorithm. An approximately 1° pencil beam rotates at approximately 1.1 rpm and changes elevation incrementally so that it sweeps out the total surveillance volume in a series of four separate slices or cuts (called beam 0, beam1, beam 2 and beam 3) followed by a short period of idle time during which software constructs a synthetic image (known as beam-S) from the four real images before the cycle starts again.

Weather radar scans timed at 1400, 1415 and 1430Z, 23 April 2007 were obtained in BUFR file format thanks to the assistance of Tony Pallot, Principle Meteorological Officer, Jersey Airport Met Office.[54] The basic product of each scan is a set of four images from the four elevation cuts having a horizontal resolution of 2km. The antenna boresight elevations are:

Beam 0 = 0.5°,
Beam 1 = 1.0°,
Beam 2 = 1.5°,
Beam 3 = 2.5°.

Beam-S produces a cleaned synthetic image by inserting higher elevation data into the beam-0 image according to a map of permanent clutter areas.

The three raw 0.5° (beam 0) images are shown in *Figs. 15, 16 & 17*. The coloured bars on the right are scales showing different levels of reflectivity in dBZ.[55] It was established that the times given are in fact the start times of the beam-0 cut in each case (although this is not actually the first in the sequence) so that the beam-0 image from the 1415 scan in *Fig 16* shows us the 0.5° rotation from about 1415-1416Z. This 60-second scan is therefore the only available weather radar cover at the relevant altitude during the known visual sighting period.

The poor pixel resolution is obvious at a glance, as is an apparent displacement and/or scale mismatch between the echo video and the map overlay,[56] making it difficult to judge echo location reliably from this image. The resolution cell has effectively the 2km x 2km range and azimuth dimensions of the display pixel (coarser than the true electromagnetic resolution), and assuming a depth of 1° the cell volume is about 4 km^3 at a distance of 50km, including the ocean surface and the atmosphere up to about 3000ft altitude.

A few pixels south and north of Guernsey contain very weak reflectivity which could be approximately in the line of sight from the *Trislander*, and there is a weak signal intensity in one pixel whose correct location *might* arguably be a few nautical miles south of the Casquets in the area of the Casquet Banks, which is near the rough triangulated position of UAP #1.

The Jersey Met Office shipping forecast for the area limited on the west by the 3°W line of longitude (about 25nmi west of Guernsey), valid for the 24 hours starting at noon on April 23

54 The authors also acknowledge the assistance of Dr. Miguel Rico-Ramirez of Bristol University in sharing software files necessary for visualising the radar data.
55 Z is reflectivity. The difference between any two colour bands is a constant logarithmic ratio of received power measured in decibels.
56 A similar mismatch was found to have been noted in published meteorological research work using this radar. See *Appendix D.*

(about 2 hours before the start of the sighting) mentioned the possibility of occasional rain spreading in from the west, but no weather reports indicate precipitation in the Guernsey-Alderney area at the sighting time.

As for low altitude aircraft: The Blue Islands *Jetstream* would have been passing through FL30 sometime during the 1415 beam-0 cut, but it was nearly 20nmi away at that time; and the FlyBe BAe146 (Jersey 912G) would have been quite nearby (see *Fig.6*, *Section 2*) but reportedly above 6000ft and therefore too high to be detected. It is clear from Channel Islands Zone radio communications (*Section 2*) and the report of the Controller (*Appendix A*) that ATC was tracking no other candidate aircraft at this time.

However a Brittany Ferries vessel is expected in the area (though not very near the shallows of the banks of course[57]). It was probably detected by the Guernsey primary surveillance radar as Track B in *Fig 12* and might also have been picked up by the Jersey weather radar in conditions of mild super-refractivity (see *Section 5*).

Also, it should be remembered that the weather radar reflectivity represents the aggregate echo received from the whole 4 km^3 resolution cell. There are various other possible reflectors inside this volume - wave slopes, rocks, seabirds, small fishing boats etc - that could be sources of transient weak echo.

So the weather radar picture doesn't allow us to say there was no radar reflector near the triangulated UAP#1 location, but it doesn't provide unambiguous evidence of an unexpected or unusual echo in the appropriate location. There also appears to be no trace of echo at the triangulated location of UAP#2. It may be reasonable to say that if there were UAPs with visual dimensions in the order of hundreds of metres (consistent with visual estimates of angular size) at these locations they probably had small radar cross-section at C-band.

In weighing this result we should bear in mind that the radar has the opportunity of only one very brief sampling. At 50km range a 2km resolution cell corresponds to ~2.5° = 1/(360/2.5) = 1/144 of the 60-second antenna rotation, or about 0.4sec, and the total dwell-time of a point target in the 1° beam width would be only ~1.7sec.

* * *

In summary the radar evidence examined is not helpful in establishing the presence of extraordinary phenomena. An ATC radar echo reported below the approximate visually-estimated position of one UAP may have been associated with an identifiable surface vessel. At

[57] Paul Kelly speculated that the "possible anaprop" echo he observed in the area could have been "waves on the reef at the casquets". The Casquet banks area is to the south of the islet where Casquets Lighthouse is situated. Marine charts show the mean sea level depth over the banks reducing to as little as 3m. At the sighting time the tide was only about 2/3 of the way through its 6-hour ebb cycle. The next low tide (3.3m above chart datum, chart datum being the lowest possible astronomical tide) was at 1649Z, the previous high tide (7.4m above CD) having been at 1034Z. Thus the low tide would be about 2m below the mean tide. Assuming the mean tide on the day to be close to chart MSL then at low tide, 1649Z, the shallowest spot on the banks would still be a metre or so below the average wave height. More than 2½ hours earlier at ~1412Z, with slight sea conditions in a light breeze, there may be some doubt as to whether wave disturbance would have been significant.

the same time there are factors - use of MTI and poor sample rate - which limit the usefulness of this negative result, and pending the results of the GEIPAN study the ATC data files have not yet been examined to a level of detail that would completely rule out the presence of interesting primary echoes.

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5) Meteorological Conditions in Sighting Area

Capt. Bowyer reported that direct sunlight was obscured (the sun at 1410Z was elevation 44° 45' azimuth 225° 20') by a "stratus" sheet a few thousand feet above his altitude extending 10 miles S of Guernsey. There was broken high cloud, some cloud to the E and a solid cloud mass to the W but a clear horizon to the SW ahead of the plane despite a haze at about 2000 ft. Air temperature outside the BN2a Trislander at FL40 was ~10°C.

As recorded in the report to CAA (*Appendix A*), forecast average winds for the Southampton-Alderney fuel calculation were SW 8 knots.[58] The Alderney Airport surface weather report at 290 ft (88m) AMSL for 1350Z was: 200° 6 knots, visibility CAVOK, temperature 14°C, dewpoint 11°C, QNH pressure 1021 mbar.

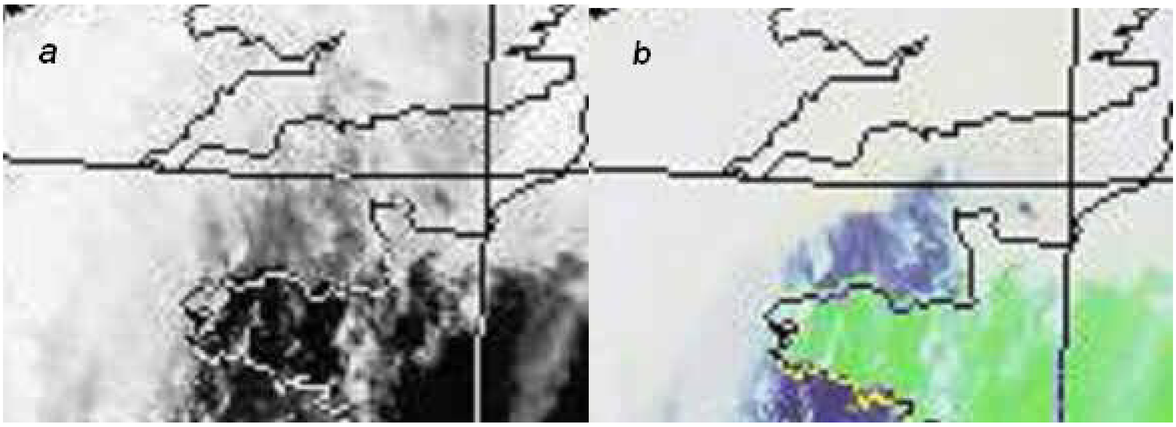

Fig 18. (a) visible (b) false colour images from NOAA 18, overhead time 14:15:34.767, 2007-04-23, average altitude 856 km, time of first line 14:08:07.745, time of last line 14:22:32.078

Other sources were consulted to reconstruct the local weather conditions in more breadth and detail. Sources included professional meteorologists, several with expertise in the Channel Islands[59], all Guernsey Airport and Alderney Airport half-hourly surface weather reports covering the period 1150 - 1550Z (*Appendix C, Table 2*), daily climate records for the month of April from Jersey Met Office (*Appendix C, Figs. 4-7*), upper air radiosonde balloon measurements of pressure, temperature, dewpoint and winds from the four nearest French and English release sites (*Appendix C, Tables 4-8*), satellite images[60], miscellaneous other UK Met Office weather products, and Jersey Met Office C-band weather radar images.

The general picture reported by Capt Bowyer seems consistent with meteorological observations and satellite images. The Guernsey and Alderney half-hourly met obs show 7/8 and 6/8 altocumulus at 12,000 and 10,000ft respectively for the previous few hours, in the process of

[58] UK Met Office forecasts and nearest UK and French balloon ascents all indicate around 20-25 knots at the cruise altitude. Our flightpath reconstruction does not of course depend on a wind calculation because we are using the radar plot.
[59] See *Acknowledgements*
[60] Courtesy of Dundee University Satellite Receiving Station http://www.sat.dundee.ac.uk/.

clearing at about the time of the observations, and 7/8 cirrus at 25,000 ft (*Appendix C, Table 2*) The UK Met Office pressure chart, 1200Z , 23 April 2007 (*Appendix C, Fig.1*) shows an upper cold front moving in from the W ahead of a low-level cold front, and a weak warm front retreating to the E. Images from the 1415Z NOAA 18 satellite pass (*Fig.8*) are of poor resolution but show the general situation of a dense cloud mass associated with the frontal system to the W. An earlier MODIS[61] image taken at 1328Z with higher resolution to 250m (*Fig. 19*) shows a chaotic cloud system with divergent winds associated with the approaching cold front. Hooked plumes of high-level *cirrus uncinus* to the W of Guernsey indicate wind shear at around 25,000 ft possibly associated with the frontal surface. A number of jet contrails are visible at high altitude.

Fig. 19. MODIS image, 1328Z, original resolution 250m. Note complex cloud features The west side of Jersey is visible at the bottom-centre of the picture and the Cherbourg peninsula of the French mainland on the right. Alderney is obscured by cloud close to the centre of the picture (courtesy Dundee University Satellite Receiving Station).

Unfortunately no regular radiosonde balloon ascents are made in or near the Channel Islands. This means that almost no direct temperature, pressure, dewpoint or winds aloft measurements exist for the column of atmosphere over the area of interest. However some conclusions are possible from surface reports and other meteorological data and scheduled balloon ascents from surrounding sites in France and the UK.

[61] The Moderate Resolution Imaging Spectroradiometers, carried on NASA's Terra (EOS AM) http://terra.nasa.gov and Aqua (EOS PM) http://aqua.nasa.gov earth observation satellites, image the earth regularly in many bandwidths. Images in the red and infrared are produced at resolutions down to 250m.http://modis.gsfc.nasa.gov/about/

The UK Met Office's noon synoptic pressure chart shows isobars to the N and W of the area lying roughly SW-NE, indicating the tendency of the geostrophic wind associated with the low pressure centre to the NW of the British Isles. To the SE of the area most of the continent lies under a rather flat pressure field with few isobars. High pressure is found to the S along the Mediterranean.

The nearest scheduled radiosonde upper air profiles were obtained[62] for Brest in Brittany, Trappes in inland France and Herstmonceux and Camborne in Southern England (the 1200Z ascent readings for these stations along with station information and sounding indices are shown in *Appendix C, Tables 4-7*), together with the surface wind and temperature chart for mainland France (*Appendix C, Fig*. 2).

The noon chart of surface winds in France (focusing particularly on north-western France) shows the winds generally rotated to the S of W. The winds aloft were generally force 4 - 7 (a moderate breeze to a moderate gale) while surface winds were generally force 2, a slight breeze.

The Jersey Met Office 1300-1800Z aviation forecast for the Channel Islands area (*Appendix C, Fig.3*) predicted winds from 230° at 10,000ft, 220° at 5000ft and 210° at 1000ft. The average surface winds actually measured at Guernsey and Alderney between 1150 and 1550Z were 195° and 189° respectively. The speeds of the winds aloft were forecast by Jersey Met as 15-30kts through 2000-18,000ft , and by the UK Met Office Form 214 forecast (for the north of the area, *Appendix C, Table 1*) as 20-25kts at 1000ft and above. Measured surface wind speeds were only about 6-7kts.

The Brest noon temperature profile is thought to be the most directly relevant to Channel Islands conditions on the day. Brest soundings are reputed to be typically somewhat "bland"[63], nevertheless there is no inversion on the Brest (or Trappes) profile below about 40,000 ft. Small low-level inversions at Camborne and Herstmonceux in the UK were determined to have causes not directly connected with conditions in the Channel Islands area (see below).

Sea surface temperature (SST) measurements were of interest. These were available for St Helier, Jersey, St. Peter Port, Guernsey, and the Channel Light Vessel. Satellite infrared sea surface temperature maps were also obtained courtesy of the French oceanographic agency IFREMER.[64] (Unfortunately valid data for April 23 2007 were limited due to cloud and haze.)

An estimate of the vertical air temperature profile(s) in the line of sight was considered especially important. Bearing in mind that the direct physical measurements available are incomplete, the evidence for temperature inversions of various types in the sighting area was considered as follows.

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[62] Courtesy of the Dept of Atmospheric Science, University of Wyoming College of Engineering http://weather.uwyo.edu/upperair/sounding.html

[63] Frank LeBlanq, Jersey Met Dept, email to Tim Lillington, Guernsey Airport Met Office, & Martin Shough, 27.07.2007

[64] *Institut français de recherche pour l'exploitation de la mer.* http://www.ifremer.fr/francais/index.php. Special thanks to Francis Gohin, Département Dynamiques de l'Environnement Côtier, IFREMER BREST

Surface advection inversion

As mentioned, surface winds across the Channel Islands zone were light and generally southerly, in the direction of the pressure gradient between the falling high pressure over the Mediterranean and the cyclonic low pressure centre to the NW of the UK. These winds are bringing warm air off shore from Brittany where noon surface temperatures (*Appendix C, Fig. 2*) rose into the low twenties. Warm air advected over the cooler sea in this way might well establish a temperature inversion in the marine boundary layer. Clearly we are interested in the atmosphere all along the line of sight from the area north of Alderney to Brittany (and beyond), and in conditions of off-shore advection the profile over the Channel Islands area might be rather different from that over the coastal area.

First, the UK Met Office Form 214 upper air forecast (six levels between 1000 and 24,000 ft) for position Lat 50°N Long 02°30'W, valid 0900-1500UTC, 23 April 2007, was obtained (*Appendix C, Table 2*). This is an ocean location some 20nmi NW of Alderney and is merely representative of a large sea area containing the sighting location. The Form 214, though only a forecast, was the most local upper air weather product available.

Interpolating these upper air forecast temperatures with the FL40 temperature recorded by Capt Bowyer (~10°C) and surface temperatures recorded at Alderney or at Guernsey suggested the possibility of a nonstandard temperature lapse rate in the lowest couple of thousand feet (*Table 2*)

Alt	292	335	1000	2000	4200*	5000	10000	18000	24000
a) T°C	+14		+14	+14	+10	+09	+00	-13	-26
b) T°C		+16.5	+14	+14	+10	+09	+00	-13	-26

Table 2. Possible temperature profiles over the islands of a) Alderney and b) Guernsey based on Form 214 interpolating Alderney 1350-1420Z and Guernsey 1350-1420Z surface temps (averaged) and Capt Bowyer's report of 10°C @ FL40 north of Alderney
**Approximate true altitude AMSL of FL40 based on Alderney QNH pressure setting.*

These profiles suggest temperatures generally warmer than average through the first few thousand feet and an isothermal gradient (no lapse) either from ~300 to 2000 ft or through the 1-2000 ft layer.

However an inquiry to Anthony Pallot (Principal Met Officer, Jersey Meteorological Dept) elicited the opinion that neither of these land surface temperatures can be extrapolated to conditions over the sea, and moreover that the true upper air temperatures probably differed somewhat from the Form 214 forecast.

The sea surface temperatures recorded at Jersey and St. Peter Port, Guernsey on 23 April were

12.2°C and 11.8°C respectively.[65] This suggests a possible temperature inversion in the first 1000 ft over the sea. Based on knowledge of the actual conditions in the area on the date Tony Pallot's best estimate of the temperature profile over the sea between Guernsey and Alderney is shown in *Table 3*. This profile adheres quite closely to the local area 1300-1800Z aviation forecast for that day.

Alt (ft)	surface	1000	2000	5000	10000	18000	24000
T°C	12	15	14	10	0	-15	-25

Table 3. Best estimate of vertical temperature profile over sea between Guernsey & Alderney

Here a surface inversion gradient of 2°C/kft suggested by the Form 214 upper air forecast is modified to a 3°C/kft gradient over sea.[66] This would be "reasonably typical of a profile in a warm sector". This conclusion was independently confirmed to us by Jersey meteorologist Frank LeBlancq: "(T)here was an inversion on the day but it looks like only 2 or 3C, whereas a good inversion would be (say) 6C or so."[67]

Conditions south of the Channel Islands area were further investigated for us by the French government agency Meteo-France who kindly performed a computer numerical simulation at our request based on all data available to them. The representative location for the profile was coastal water at 48.9N 3.4W, off shore from Lannion, Brittany, (which lies close to the line of sight to the UAPs from the Trislander). The simulation was run for 4 hours between 0900Z and 1300Z with a geographical resolution of 0.1° lat/long and for height levels between 0 and 1500m. The result is shown in the skew-T diagram in *Fig.20*, which represents the vertical profile predicted for 1300Z, a little over one hour before the sighting time, and it is easy to verify the feature described by Thierry Jimonet of Meteo-France, Toulouse, as follows:

> . . . near the Breton North coast, we find a rather clear inversion in the very low layers between 0 and approximately 200m above the sea. The pressure at sea level is 1021hPa and the temperature 12.4° whereas the model indicates a maximum temperature of 18.1° for 1014 hPa. That is to say a vertical gradient of approximately 5° for 50m. . . . In this particular case, the model seems to indicate a rather local phenomenon (near to the coast because of a difference in sea/ground temperature) . . . reaching a maximum towards 13-14h UTC.[68]

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[65] The average of 12°C is corroborated by the Jersey Met Office shipping forecast figure issued at noon, 23 April, and also by Jersey Planning & Environment Dept, Fisheries & Marine Resources, who reported (email 23.07.07) temperatures "of the order of 12 degrees Celsius". The Channel Light Vessel SST measurements give a mean of 11.8°C and max of 12.2°C. The CLV is far to the N in deeper water that one might expect to be if anything cooler, suggesting that SST in shallow coastal water after a recent warm spell might be significantly above the 12°C Channel islands mean. However NOAA-18 satellite IR measurements indicate SST in the range 9.5 - 11.5°C, although the map shows very few reliable pixels in the area due to cloud and haze. On the other hand the Meteo-France ALADIN numerical simulation utilises 12.4°C for coastal water near Lannion.

[66] The revised estimates for the elevated levels in *Table 2* would suggest a ~3°C/kft inversion over land at Alderney, and a slightly superadiabatic lapse rate (-3.75°C/kft) above Guernsey, but these are probably not very meaningful.

[67] Email from Tony Pallot to Martin Shough, 25.07.07; email from Frank LeBlancq 27.07.07.

[68] Email from Thierry Jimonet to Jean-francois Baure, 03.09.07

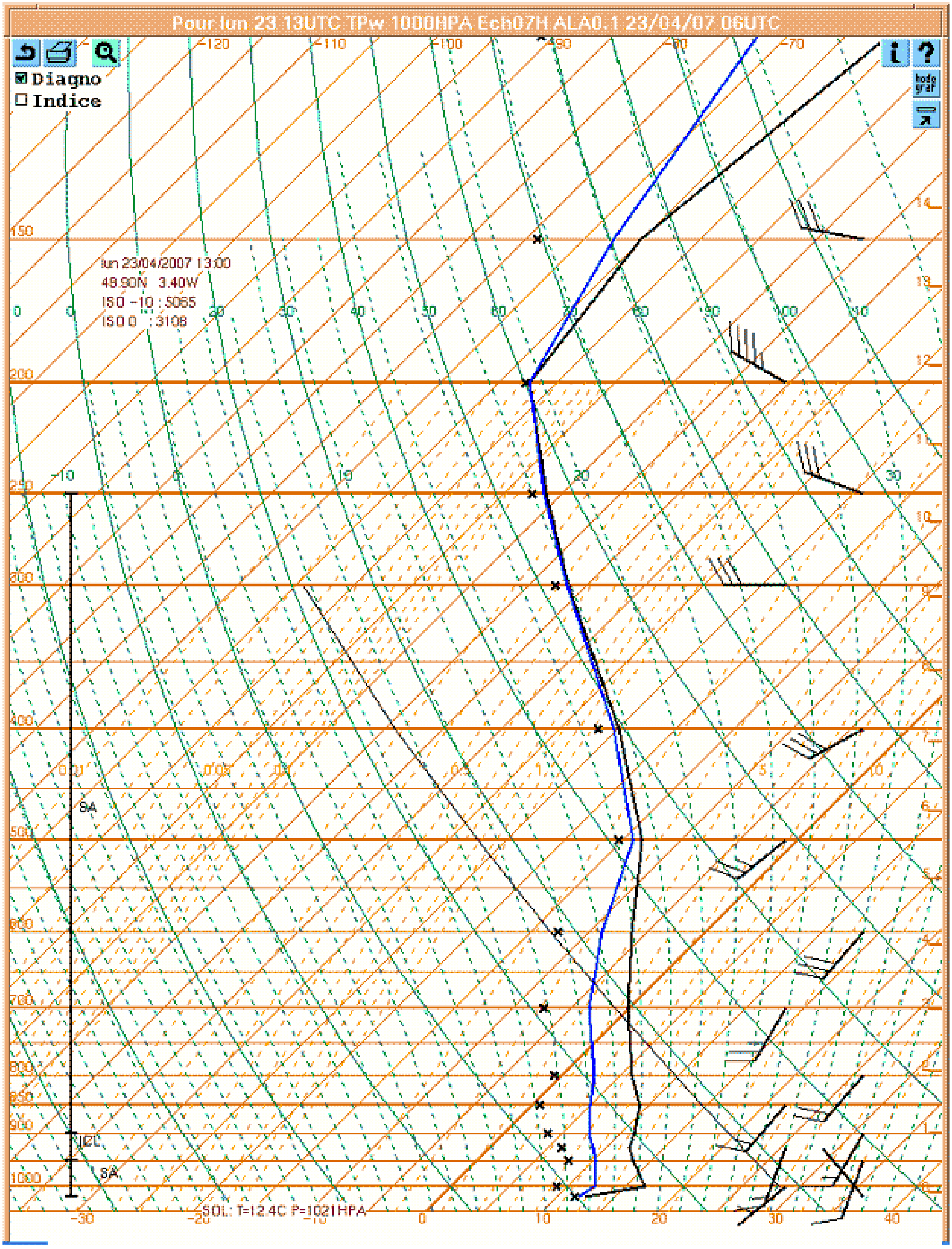

Fig.20. Skew-T plot of dry-bulb temperature (black curve), dewpoint, frostpoint and winds for 48.9N 3.4W, 23 April 1300Z produced by Meteo-France ALADIN numerical simulation model.

Jimonet points out that Spring is a favourable season for the development of such advection inversions. It was not possible to say how far from the coast the local inversion gradient might extend, but near to the coast, at just under 10°/100m (33°/1000ft), it is on the verge of a trapping gradient, where light rays would be refracted with the same radius of curvature as the earth (33 arcsec/km). This surface layer of ~200m (660ft) depth might therefore act as an optical duct.

We were also interested in a possible elevated inversion which might cause sharp changes in refractive index at around the altitude of the haze layer (since the optical lines of sight to the UAPs from the Trislander were at times reported as tangential to this layer). Although the Meteo-France numerical model[69] produces no sign of an elevated inversion we sought to check this against direct and indirect evidence in surface met observations and balloon ascents.

Anticyclonic inversion

According to the Jersey Met Office climate graphs (*Appendix 9*) April 2007 was slightly warmer, sunnier and drier than the 1971-2000 period average, and the few days previous to April 23 had been very slightly warmer and sunnier than most of the month, although the pressure was falling somewhat below its high point earlier in the month. However this seems to reflect the fact that the area was in what is called a warm sector between a retreating warm front and an approaching cold front, and these cyclonic frontal movements associated with the low to the NW of the UK appear to dominate the weather in the area. Such conditions are far from the anticyclonic conditions of building high-pressure that are often associated with severe stratification.

Frontal inversion

The frontal surfaces bracketing the warm sector slope upward, away to the west in the case of the approaching cold front to the W, and to the east in the case of the retreating warm front to the E. Each of these surfaces can be associated with an inversion of the temperature profile. For example the approaching cold front intrudes a wedge of colder air at low level and the warmer air of the warm sector will be advected over the top of it.

A small low-level inversion was present at Herstmonceux (E. Sussex). Tony Pallot advises that the weak warm front sloping E into Belgium was probably responsible for this. But the line of the front was over 100nmi E of the sighting area, whilst the cold front sloping to the W was still too far west to be responsible for a similar small inversion on the profile at Camborne (Cornwall), which is itself about 115nmi W of the sighting area.[70] A frontal inversion appears to be ruled out.

[69] Note northwesterly on-shore surface breeze developing by 1300Z (UTC). See Section *6.d.ii*.
[70] We are advised that the Camborne inversion was probably a local stratification caused by sea-cooled air streaming over the Cornwall peninsula (email from Tony Pallot to Martin Shough, 26.07.07), causing a thick mist as revealed in RH nudging 100% throughout the first few thousand feet.

Elevated subsidence inversion

Subsidence inversions can occur in a warm sector between a retreating warm front and an approaching cold front, almost always at higher levels and usually above the freezing level. However although the observed dissipation of the altocumulus layer at 10-12,000 ft may have been caused by adiabatic warming associated with subsidence at this level, Tony Pallot considers that this is unlikely to have a bearing on conditions near the ground. The fact that surface pressure was actually falling at the time ahead of an approaching cold front suggests ascending (cooling) air at low levels rather than descending (warming) air, so a subsidence inversion at low level does not seem likely.[71]

Nevertheless we pursued this question further on the strength of an extremely dry level on the noon Brest profile at about 2500ft (see *Fig. 21*). Might not such a layer of dry air indicate the top of a subsidence inversion? This is often the case; but not, we were advised, in this instance. The overall dynamics of the atmosphere are inconsistent with a subsidence inversion at this low level. Rather this layer is believed to be what is known as a "dry air intrusion" caused by continental air being forced north parallel to the frontal zone, possibly from as far south as the Iberian peninsula.[72]

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1011.0	95	18.2	8.2	52	6.79	220	10	290.4	310.0	291.6
1000.0	188	16.8	6.8	52	6.23	220	11	289.9	307.9	291.0
968.0	463	12.8	2.8	51	4.86	224	13	288.6	302.7	289.5
935.0	754	12.6	-18.4	10	0.96	229	15	291.3	294.4	291.5
925.0	844	12.6	-5.4	28	2.78	230	16	292.2	300.6	292.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fig. 21 Extract from the Brest 1200Z radiosonde ascent profile

Elevated advection inversion

Another possible cause of an elevated inversion near the haze layer is where warm continental air is advected over a relatively cool and relatively deep marine layer in such a way that the marine layer remains undisturbed. A sharp elevated gradient might occur at the boundary between the two air masses.

But there is evidence that rather than remaining cool through the first 2000ft the air is warming, creating the low-level marine temperature inversion already discussed. We were advised by Tony Pallot that advection of still warmer air above this level was not a plausible mechanism on the

[71] Email from Tony Pallot to Martin Shough, 25.07.07

[72] It is also possible that dry air is created ahead of a katabatic front, when the front is moving slower than the air ahead of it so that air tends to descend down the frontal surface. But this usually occurs from high altitudes down to about 3000m, and although the mechanism could be responsible for adiabatic evaporation of altocumulus cloud at this level the much lower Brest dry layer seems more likely to be associated with a deliquescent haze layer reported by observers at around 2000 ft and which Capt Bowyer described as "due to bad air from the continent". Tony Pallot would expect the Brest layer to be fairly localised but opines that the intrusion could have extended northward to the Channel Islands area by that afternoon (email to Martin Shough, 16.08.07)

day in question. Balloon ascent data suggest that there might be advected *drier* air from the continent above 2000ft,[73] but not significantly warmer. At this time of year the effect of surface temperature on air at this level, as opposed to the surface, is minimal (about +1° at most).[74]

This opinion is corroborated by the Meteo-France numerical simulation, which predicts a significant local advection inversion at low level over Breton coastal waters south of the Channel Islands, steepest through the first 165 ft (~50m), but no features of note above about 1000mbar (~630ft, 200m).

We attempted to further test these expert theoretical models against real-world observations by investigating the performance of the Jersey Airport Meteorological Department weather radar during the sighting time. Our reasoning was that an optical duct would potentially be a stronger duct at radar wavelengths, and a map of the ground clutter reflectivity could be regarded as a direct sampling of the microwave propagation environment in the sighting area.

We adopted several approaches. Firstly we wished to simulate the C-band weather radar picture by computer raytracing. By varying the effective ray curvature over a digital elevation model of the area we attempted to reproduce the ground clutter pattern and from this infer the radar refractivity at low elevation. On the basis of this we then proposed to use the well-known temperature/humidity refractivity relations to plot optical raypaths as a function of those in the centimetre region. In parallel the observed echo from the islands during the sighting period was compared with published historical observation data from the same radar and local expert advice was sought.

The best overall fit to the observed clutter pattern in the Channel Islands area was obtained with a ray curvature of +22" per km horizontal distance, a slightly super-refractive curvature but far short of radar trapping (22"/km corresponds to a refractive index gradient of approximately -32 *N*-units per 1000ft. Normal propagation in the standard atmosphere is taken to lie between 0 and -24 *N*-units per 1000ft; trapping occurs with gradients larger than -48 *N*-units per 1000ft). The height ASL of the Jersey C-band antenna would lie within the thickness of the expected Breton coastal optical duct, but it would be sited between the strong ducting region to the south and the region of weaker marine inversion in the vicinity of Guernsey and Alderney to the north. We would therefore expect that low elevation radar raypaths entering the duct could propagate with especially enhanced efficiency to the south, returning echo from coastal topography of Brittany with unusual strength up to about the 200m contour. This fits the radar evidence indicating that super-refractivity was most noticeable and most variable to the south, and declining over time, suggesting a weakening duct, whilst echo from the islands to the north shows less variability and neither Alderney nor the nearby northern coastal hills of the Cherbourg peninsula return any echo at all.[75]

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73 The visibility above the 2000ft haze layer was said to be good, to 100nmi. Andy Young, an atmospheric scientist at San Diego State University, points out to us that this is an indicator of dry air. The optical cross-section of haze particles has a strong dependence on relative humidity. This is the main reason why a haze layer may often be diagnostic of an inversion, since there is a large RH jump associated with the temperature jump at the top of the layer (email to Martin Shough, 01.09.07).

74 Email from Tony Pallot to Martin Shough, 04.09.07.

75 There is evidence of probable topographical masking to the NE of the radar, but historical data from 2004 (see *Appendix D*) prove that these areas do contribute significant clutter in super-refractive propagation conditions.

So we found radar evidence qualitatively consistent with the general atmospheric situation described earlier, although reliable inferences about the strength of optical refraction were unfortunately not possible, mainly because of uncertainty about the vertical humidity profile, a variable on which radar refractivity is powerfully dependent. (A fuller account of these investigations is given in *Appendix D*).

* * *

In summary, we conclude on the basis of meteorological evidence that there is a likelihood of a significant inversion in the first ~200m over the cool sea to the S of the Channel Islands area, strong near the Breton coast where it probably reached an optical ducting gradient, becoming weaker further north. There seems to be neither evidence of, nor a plausible mechanism for, an elevated temperature inversion - at least in the lower atmosphere below the freezing level.[76] (Detailed discussion of the optical effects of temperature, pressure and humidity gradients is in *Section 6.*)

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[76] The highest angular elevation of the visual line of sight to the UAPs from ~4200ft AMSL was approximately tangential to the 2000 ft haze-layer horizon. Most of the time the LOS actually intersected the sea. Therefore the haze layer, well below the 10,000ft freezing level, represents the approximate *maximum* altitude of any relevant optical duct. See *Section 6(d), Surface reflections and mirages.*

6) Hypotheses

We have scored each of sixteen hypothesis on the following scale:

0 = very implausible
1 = somewhat implausible
2 = barely plausible
3 = somewhat plausible
4 = very plausible
5 = definite identification

a) sundogs

It is immediately noticeable that the visual LOSs to the UAPs from the *Trislander* were not far from the azimuth of the sun. This fact was indeed noted by the witnesses, two of whom also described the light as “sunlight” coloured.[77] This coincidence invites speculation that the UAPs may have been caused by some kind of atmospheric-optical reflection or refraction effect.

Sundogs (or parhelia) became a favourite hypothesis of some public commentators within a very short time of the event.[78] Sundogs are fuzzy patches of light caused by refraction of the sun’s rays through hexagonal platelet ice crystals above the observer. We were easily able to confirm the presence of ice clouds above the ~10,000ft freezing level (*Fig.22 & Section 5*), thus between the *Trislander* and the sun. But not below the *Trislander* (air temps >10°C) and so not on the observer’s LOS to the UAPs near the horizon.

The optical geometry dictates that sundogs occur close to the 22° halo around the sun. They tend to be elongated with the major axis of symmetry lying vertically because of the way the ice plates lie in the atmosphere, but do sometimes show spectral “tails” extending radially away from the sun, to left and right, for a degree or two. But a pair of sundogs would bracket the sun at about 45° elevation above the horizon, about 22° either side of the disc[79]. Two lights near the horizon, almost directly below the sun and just a few degrees apart, are not sundogs. We can be confident of this on the grounds of the gross geometry without going on to consider their “brilliance”, “extremely well-defined” outlines and curious internal detail.

The common sundog is only one of an array of light halo phenomena that can be caused by ice crystals, but most of these are even fainter and consequently rarely seen. In rare conditions such as most often occur in polar skies a complete display can be seen with a whole complex of superimposed arcs and nodes of increasing fugitiveness at larger angular distances. There is even

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[77] One of these nevertheless thought that the source was emissive, not reflective, and this witness along with one other mentioned “orange” hues, suggestive more of haze-scattered sunlight than direct light from a high sun.
[78] On the basis of early newspaper stories a local author, Michael Maunder, published the sundog theory in the bi-weekly *Alderney Journal,* volume #873. A letter in response from Capt Bowyer appeared in #874. Mr. Maunder retracted the theory on the basis of information provided by Capt Bowyer and by the present authors. He appears to have reverted to a version of it in *A Report on the Putative UFO Seen Over Alderney,* Maunder/Speedybrews 2008.
[79] In fact sundogs are bright nodes at the intersection of the rarely seen circumscribed halo and parhelic circle, and the higher the sun the further out the sundogs will appear. In this case they would have moved out several degrees from the 22° halo along the parhelic arc, appearing subjectively even higher.

a faint secondary halo occurring at 46° from the sun, which could at least have intersected the horizon in this case (had there been ice crystals present at low level). But none of these phenomena resembles the UAPs reported.

It would be possible - given the presence of a layer of ice crystals below the observers - for a brilliant terrestrial source (such as a reflection of the sun from the sea) to generate a 22° ice halo and also to appear flanked by a pair of "sundogs" ~44° apart. But the reflection geometry, like that of a rainbow, is always fixed in relation to the positions of the observer and of the source, and the internal angles between the nodes and arcs of the halo do not change, whereas our UAPs (which were of course neither 44° apart nor each 22° from any visible bright source) moved laterally *relative to one another* by several degrees.

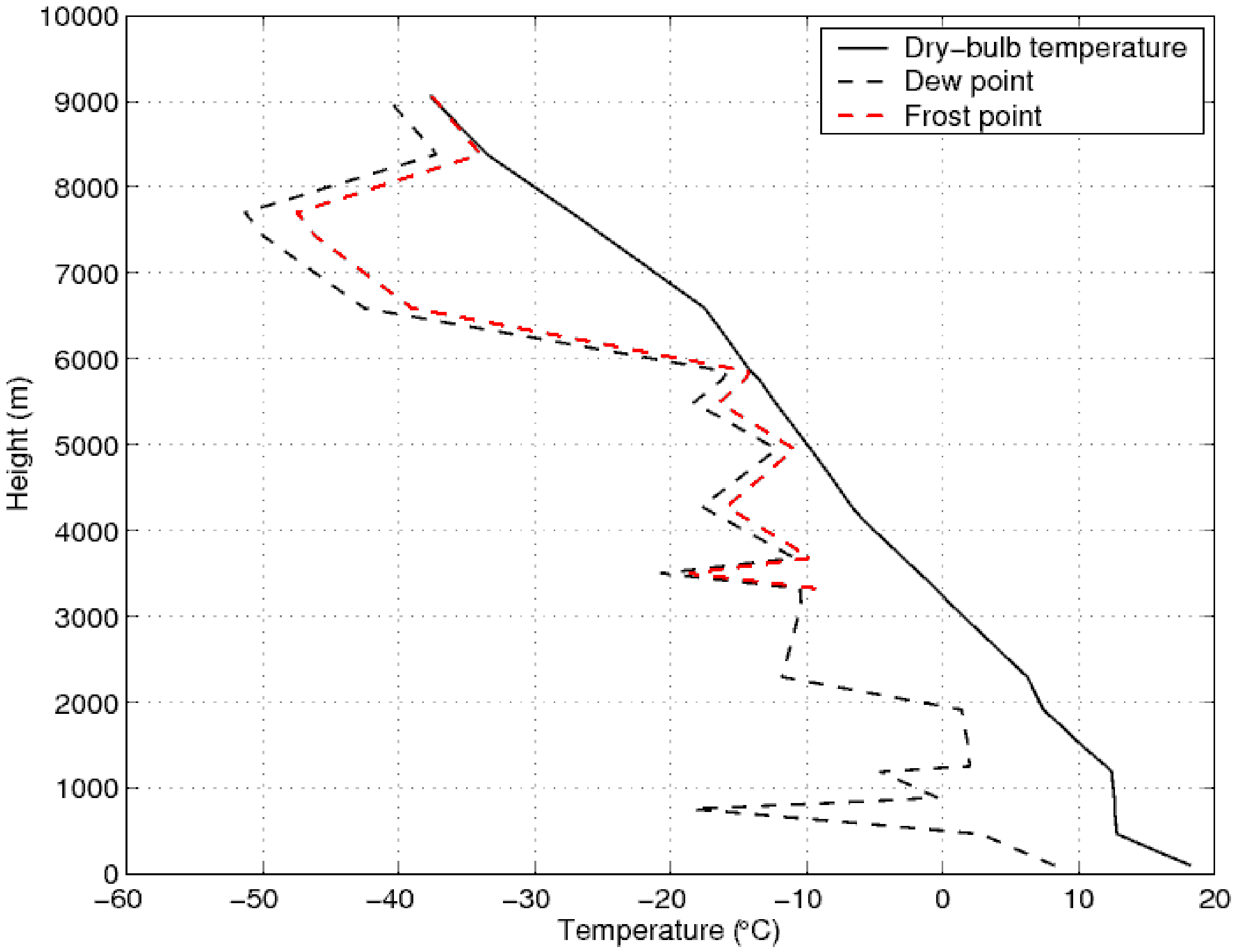

Fig.22. Brest radiosonde ascent, noon, April 23 2007, showing freezing level ~3200m. The frost point is the temperature (slightly warmer than the dew point) at which saturated air begins to condense preferentially over ice particles.
(graph courtesy Dr. Robin Hogan. Reading U.)

The sundog hypothesis is also not very useful to explain the *Jetstream* pilot's observation on a near reciprocal line of sight, looking away from the sun. The only remote possibility for explaining an object on this bearing as an ice halo would be a 120° sundog on the complete parhelic circle. In a very well developed parhelic display there are in principle two of these paranthelia , 60° either side of the anthelion (a faint patch on the parhelic circle opposite the sun), therefore at 345° and 105° azimuth. It seems possible to reconcile a 345° azimuth with the pilot's 8 o'clock LOS within 10° or so.

However these rare paranthelia are faint elliptical blurs of light not much brighter than the parhelic arc they sit on, which would also usually be visible, and more importantly the elevation of the parhelic circle is that of the sun, i.e. in this case ~ 45°, whereas the UAP was observed at a depression angle below the horizontal. This theory doesn't fit the pilot's description of a "yellow/beige" oval in any particular.

Plausibility (0 - 5): 0

b) Subsun

Related arguments apply to a possible subsun, which is also an ice halo phenomenon. A subsun is commonly seen in isolation, but is part of a complex display called a subparhelia, mirroring below the horizon the appearance of the normal parhelia above. The subsun is a virtual image of the sun and occupies the equivalent position in the inverted display, which is produced in this case by a layer of platelet ice crystals *below* the altitude of the observer. For this reason subsuns are commonly seen from aircraft.

A subsun appears as a single patch of light, varying from a near-specular solar image to a fuzzy ellipse (in rare cases surrounded by concentric ellipses called Bottlinger's Rings), with a vertically oriented major axis that further devolves into a vertical streak called a sun pillar. The single subsun appears directly below the sun, which in the present case would be at azimuths between ~224° and 227°, and therefore does not explain two horizontal ellipses disposed side by side, the *western*most of which is seen always to the E of the Casquets Light.[80]

Rarely a very well developed subparhelia can produce a bright subsun attended either side by its own pair of sub-sundogs. But these will be at least 44° apart and therefore nowhere near close enough. The subsun itself would be much more prominent than the pair of sundogs. And most importantly, the depression angle below the horizon of this entire display will be equal to the elevation angle of the real sun above the horizon, i.e. about -43°, whereas the UAPs were seen within a degree or two of the horizon.

In the present case both the geometry and the meteorology are inconsistent with a subsun. Most obviously all witnesses were thousands of feet below the freezing level, which was at about 10,000ft (*Fig.22*; see also *Fig.20*, *Section 5*). There is no evidence that lines of sight could have intersected the top surface of a layer of ice crystals.

Plausibility (0-5): 0

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[80] The reflection geometry of the ice halo is bilaterally symmetrical about a vertical axis passing through the azimuth of the sun, whereas in this case both UAPs were seen (for some minutes) offset asymmetrically by several degrees to the *left* (E) of the ~220°azimuth of the Casquets lighthouse (a definite and familiar visual reference), whilst the sun was at an azimuth ~225° to *right* of Casquets and moving W (see *Fig.23*).

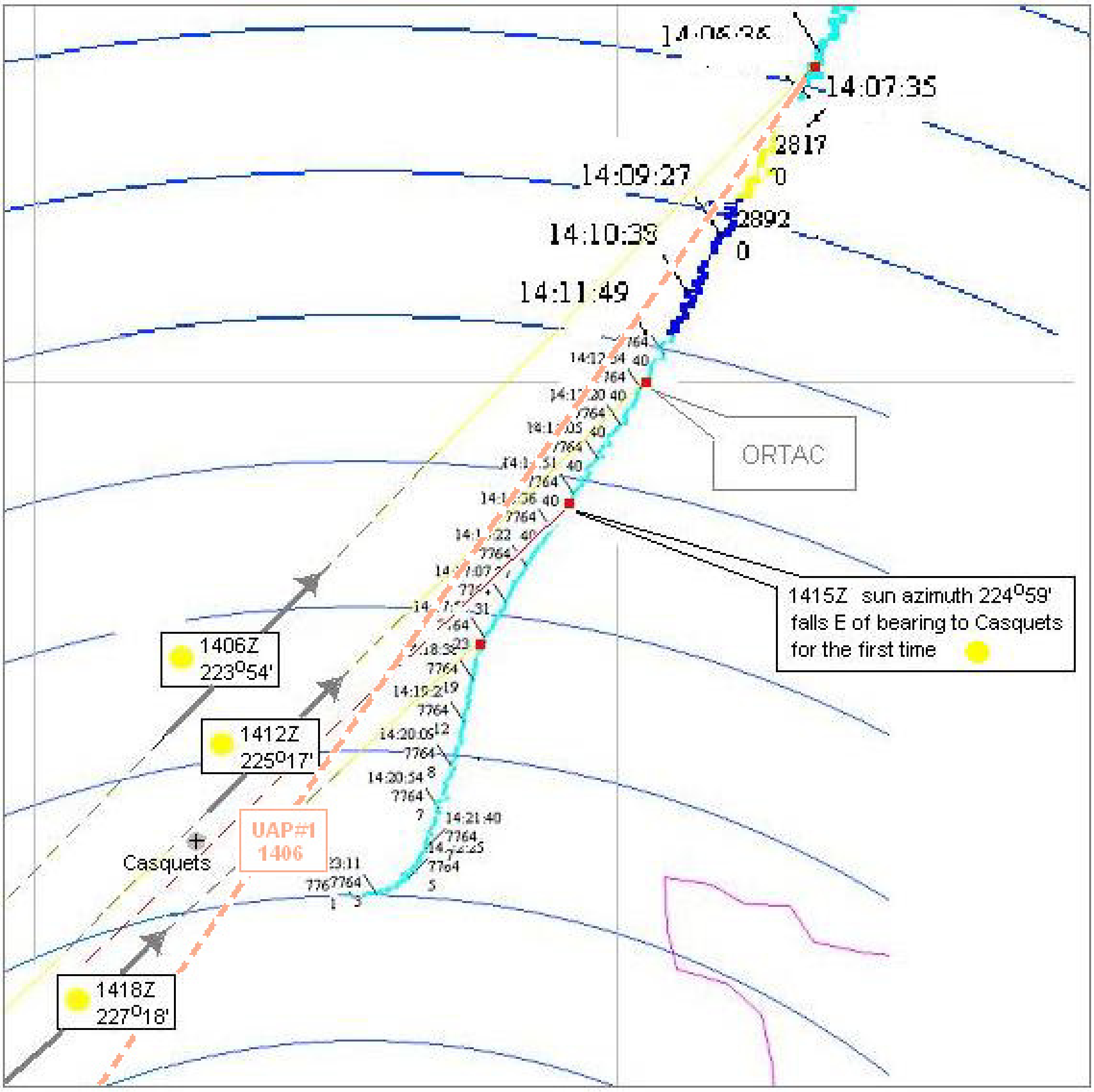

Fig 23. The solar azimuth remains West of the Casquets until approximately 3 minutes from the end of the sighting, whilst UAP visual bearings lie East of the Casquets.
The pink dotted line shows the initial bearing to UAP#1 at 1406 passing, as reported, over the island of Guernsey (see Fig.7). It is approximately 10° east of the sun azimuth.

Note: The aircraft map coordinates for times 1406Z and 1418Z were set at 50.1°N 1.8°W and 49.8°N 2.2°W respectively. Corresponding solar azimuths and altitudes were determined initially by Adastra Freestar digital planetarium running on a PC and the results checked against an on-line sun table Java calculator at http://www.jgiesen.de/astro/astroJS/rsTableWorld/index.htm written by astronomer Jurgen Giesen, which implements algorithms in a standard reference (Jean Meuss, *Astronomical Algorithms*, Willmann-Bell, 2nd ed.1998). The results shown are believed accurate to within a few minutes of arc.

c) 3rd & 4th order rainbows

Unlike the ice halos discussed above, rainbows are water droplet phenomena.[81] The common primary and secondary rainbows occur around the antisolar point, which is the vanishing point of a line drawn from the sun through the eye to the point on the celestial sphere opposite the sun. The primary rainbow appears as an arc of a circle 42° in radius. Clearly phenomena observed at the sun's azimuth cannot be primary or secondary (1st and 2nd order) rainbows.

There are however rarer 3rd and 4th order rainbows which do occur in the direction of the sun. The 3rd order rainbow is only about ¼ as bright as the 1st and the 4th order about 1/6 as bright. They are almost never visible because of the glare of the sun, but in ideal conditions with the sun occulted it is thought that they may very rarely be detected. The 3rd order bow occurs at the same radius from the solar point as the 1st does from the antisolar, about 42°, and the 4th occurs immediately outside it separated by a small gap, with the order of colours reversed.

In this case we can perhaps suppose that direct sun at ~45° elevation is shielded by cloud and by the top of the cockpit windscreen, and a 42° radius would bring the bows close to the horizon. Perhaps only a small, isolated segment of bow is caused by an isolated patch of rain droplets. There is also a region where the inverted spectra of the two concentric bows abut, in the red, which might appear as a dark area between brighter yellow regions, suggesting the idea of the "dark band" reported on each of the two UAPs.

But these3rd and 4th order bows are even broader than the common 1st and 2nd order ones and the pair would be perhaps 5° in thickness, an order of magnitude bigger than the 0.5° width of the UAPs when first observed, and the possible dark(red) area is much too wide to be a dark band in the order of 0.1° degree across or smaller.

Also to get the reported "brilliant" and "clearly defined" shapes from these very faint and elusive phenomena near the glare of the scattered light from the sun seems quite impossible. And even then the hypothetical "dark band" in the red must appear on a circumferential arc concentric with the sun; but because our UAPs are almost directly below the sun the band would lie horizontally, not cut through the UAPs vertically as observed.

Finally these bows can't occur in the absence of raindrops. Available meteorological reports and weather radar scans (*Section 4*) do not indicate rain in the sighting area.[82]

Plausibility (0-5): 0

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[81] A useful and authoritative source of information on a wide range of light effects involving droplets and crystals is the atmospheric optics websiteof physicist Les Cowley at http://www.atoptics.com. A wealth of data and applications is also available at http://www.philiplaven.com/index1.html

[82] Fogbows can be caused by suspended droplet sizes smaller than raindrops, but they are far too diffuse and faint for our purposes. However see *Section 6d.*

d) surface reflections and mirages

A number of surface reflection scenarios are possible in principle. These include (singly or in combination):

- isolated patches of sunlight on the sea caused by "god rays"
- reflections from a sun-glitter path on the sea horizon south of Guernsey
- mirage of sun-glitter reflections from sea areas over the optical horizon
- mirage of sun glitter reflections from lakes in Brittany;
- specular reflection from artificial reflectors in Brittany or on Guernsey;
- scattering of reflected light from surface sources by haze aerosol particles;
- coronal diffraction by aerosols of sunlight reflected from these sources;

i) "god ray" (crepuscular ray) sun patches

Isolated sun patches caused by narrow shafts of sunlight piercing broken cloud, sometimes known as "god rays", are one possible explanation of two lights that appear to move relative to one another on or "over" the sea. To explain the brilliance we require specular sun-glitter reflection (some issues connected with this are discussed in *Section 6.d.ii* below). At the kind of near-horizon distance required in this case the observed lateral translation equates to about 1 mile per degree of arc, so UAP #2 could be modelled as a sun patch moving, relative to UAP#1, about 3 miles E-W in 6 minutes, or a rate of around 30 knots . If UAP #1 is a nearer sun patch moving very little then the rate and direction of #2 are roughly consistent with the winds aloft.[83]

This hypothesis has several difficulties: The sighting geometry indicates an angular rotation of the #1 LOS itself through about 10°, equivalent to ~50 knots, in the direction opposite to the wind; notwithstanding this, the *differential* angular rates of motion of #1 and #2 would in any case imply a horizontal wind shear in the order of tens of knots, which is in tension with the requirements of stability and similarity of two sun patches under simultaneous binocular observation for 6 minutes; the persistence of even one such patch of sunlight with a "very sharply defined" and unchanging outline for 12 minutes seems unlikely, and the occurrence of two geometrically similar such patches, a few miles apart on the sea surface, each with an unexplained asymmetrical dark band in the same place, is more unlikely still; witnesses were questioned about the light conditions but saw no sun shafts, despite the haze, and the weather picture (*Section 5*) does not suggest the type of overcast that would produce extreme and unusual contrasts of light and shade; at the start of the observation UAP#1 was seen not only against the sea but also against the background of the island of Guernsey; at the end of the observation Capt Bowyer estimated that the elevation angle of both UAPs was above the sea horizon, such that they appeared to be near his own altitude, i.e., near the top of the 2000ft haze layer; and finally, specular god-ray patches near the S sea horizon could not explain the phenomenon sighted (at the same apparent altitude) in the vicinity of Alderney by Capt Patterson looking N.

Plausibility (0-5): 1

[83] Our hypothetical specular sun patches are not of course in the geographical locations indicated in *Fig.7, Section 3,* which assumes parallax displacements of stationary UAPs at 2000ft above the sea. The visual lines of sight do not intersect the sea surface at these local positions, but pass near the horizon.

ii) Specular "glitter path" reflections on the sea off Brittany

The reflection of the sun in a sea surface which is not perfectly smooth is a pattern composed of many glint reflections each of which is a specular reflection of the sun offered by the sloping side of a wave. So the effect is critically dependent on the wave slope, and the overall geometry of the pattern is dictated by this in combination with the sun elevation angle. As a rule of thumb, the absolute angular height of the pattern - the length of the "glitter path" - is proportional to 4 times the maximum wave slope, and the ratio of angular length to angular breadth of the pattern is proportional to the sine of the sun elevation.[84]

A sea like a perfect mirror could produce a small ellipsoidal reflection comparable to the initial angular width estimated for UAP#1, but this image would not occur near the horizon at all, it would lie close to the correct virtual distance "behind" the sea-mirror for a true specular reflection. With the sun about 45° above the horizon this virtual location would be about 45° below the horizon for an observer on the sea surface, and at a smaller but still steep angle tens of degrees below the aircraft in this case. In order to get the reflection near to the horizon we must make it much more incoherent by raising the wave heights and bringing the maximum wave slope towards ~1/4 of that depression angle, i.e., a slope in the order of 10°. This is more realistic, but the glitter pattern then caused (on open unobstructed water) by a sun at elevation 45° (sin 0.707) will be a fat vertical ellipse about 30° broad.

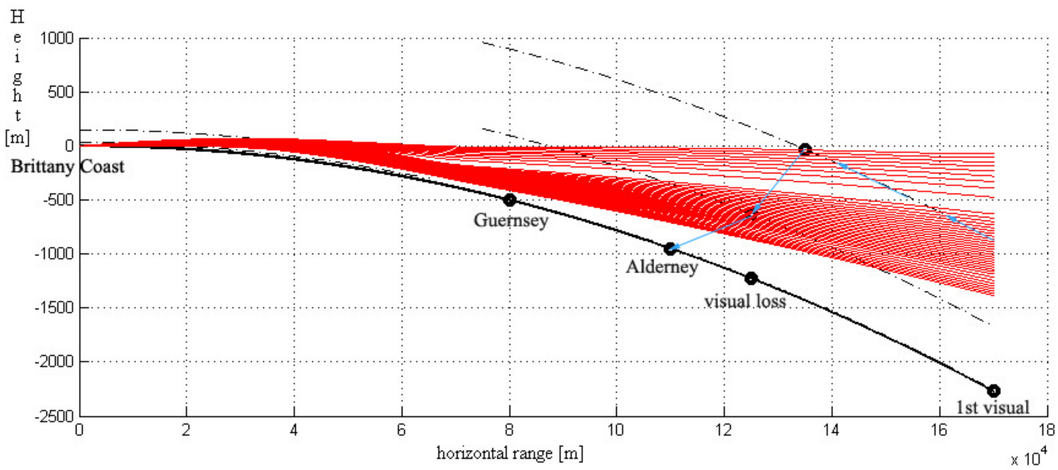


Fig.24 Initial ray tracing assuming a 65km duct (-170N/km vertical RI gradient) of depth 200m with 10km transition to standard atmosphere. (Matlab simulation by J-F. Baure)

So we require a mechanism to select separate small (order of 1°) regions of a broad glitter path at the eye of the observer. This mechanism might be either physical and/or atmospheric-optical. Physical selection would be either cloud masking or topographical masking. Cloud masking takes us back to the "god ray" theory dealt with above. Topographical masking by the coast or distant hills of Brittany might be possible. But given the small azimuth change of any such features, near the horizon at least tens of miles distant and almost directly ahead of the

[84] J. A. Shaw, Glittering Light on Water, *Optics and Photonics News, Vol.10 , 3, March 1999, pp 43-45, 68.*

Trislander, it is hard to see how regions of specular reflection could drift laterally by several degrees with respect to one another.

This relative motion of the two UAPs may seem to invite an optical theory. But optical propagation mechanisms are almost exclusively controlled by the vertical temperature structure of the atmosphere as it is in this direction that significant gradients can be established between layers lying parallel with the sea or land. This means that small *vertical* rather than horizontal displacements are typical of mirage refraction.

So this group of hypotheses is not without problems. Nevertheless the mean azimuth of the UAPs lies within a few degrees of the sun azimuth and witnesses described “sunlight coloured”, “sunlight yellow”, “sparkling” and “brilliant” light, which (notwithstanding mentions of “orange” colouration from two observers) encourages further investigation along these lines.

We considered the possibility that the source of a well-defined thin “cigar” of sparkling light might be an area of specular glitter contained by a crescent bay on the north Breton coast. A reflection 0.5° wide at 100 miles would correspond to a bay approximately 1 mile long. The azimuth discrepancy between the line(s) of sight to the UAP(s) and the azimuth of the sun might be explained by the orientation and steepness of shoaling waves that happened to present an optimum angle for specular reflection.

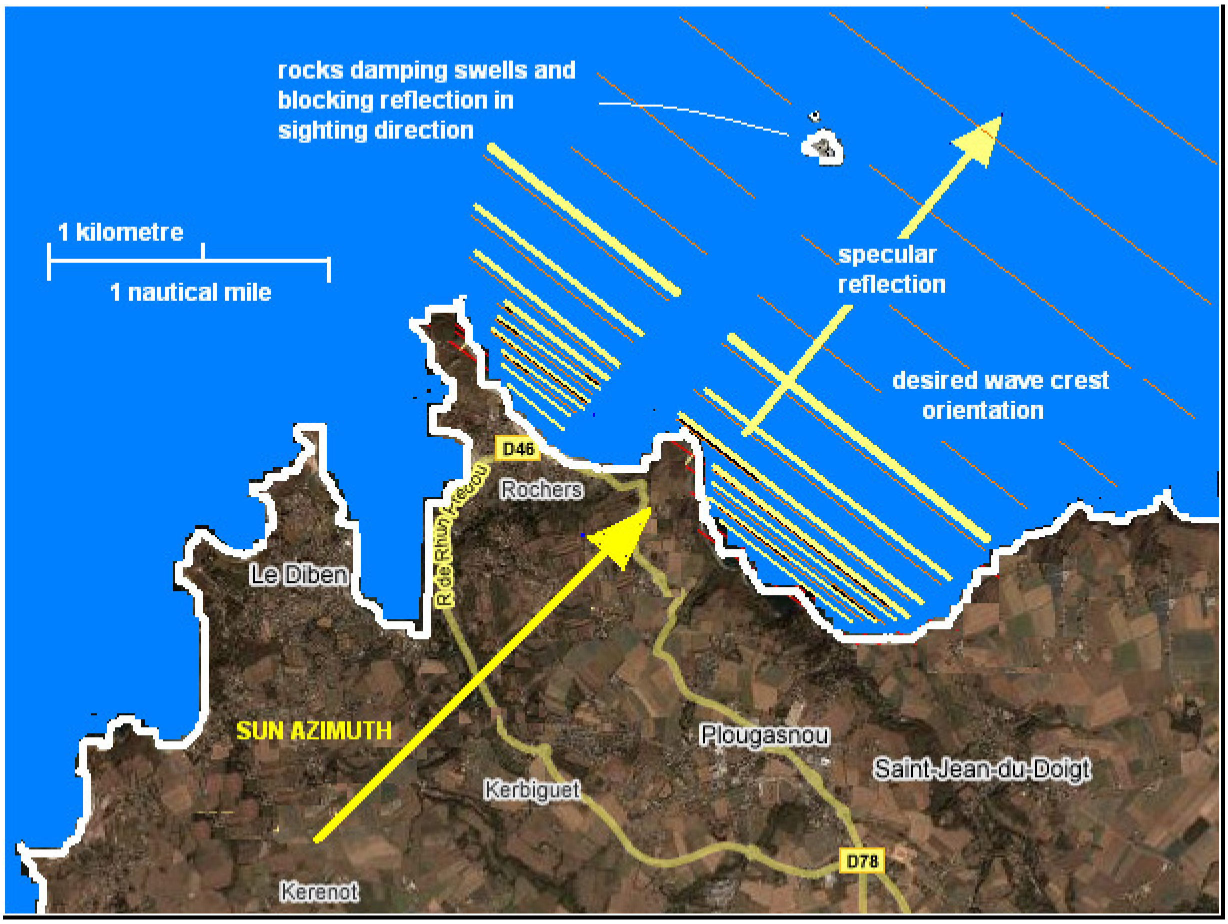


Fig.25 Optimum wave orientation for the specular reflection model

The normal optical horizon distances from the Trislander at the start and end of the observation were 69nmi and 48nmi respectively, so that it was necessary also to invoke mirage refraction in order to connect the light ray paths from the Breton coast to the observers. In this we were adapting a “mock-mirage” theory suggested to us by atmospheric physicist Les Cowley, an unusual optical geometry in which ducted light rays (rays refracted with a radius of curvature close to the 33”/km curvature of the earth and effectively trapped inside the refracting layer) escape the duct at an upward angle towards observers situated above the top of the duct.[85]

We did find evidence (*Section 5*) that there was a low-level advection inversion with an average gradient of ~10°C/100m over the coastal waters off the N of Brittany - close to a trapping gradient - diminishing by a factor 10 at some point south of the Channel Islands area. It seemed possible to us that light rays ducted from the Breton shore might leak from the weakening duct at some point south of Guernsey and present an over-the-horizon “mock mirage” image of a bright sea bay to observers at 4000ft many miles away. (In principle a duct might even trap sun glitter reflections from as far away as the Bay of Biscay, but raypaths from the Bay of Biscay cannot couple into this Breton coastal duct which extends only to about 200m altitude, significantly lower than the Breton hills in the line of sight.)

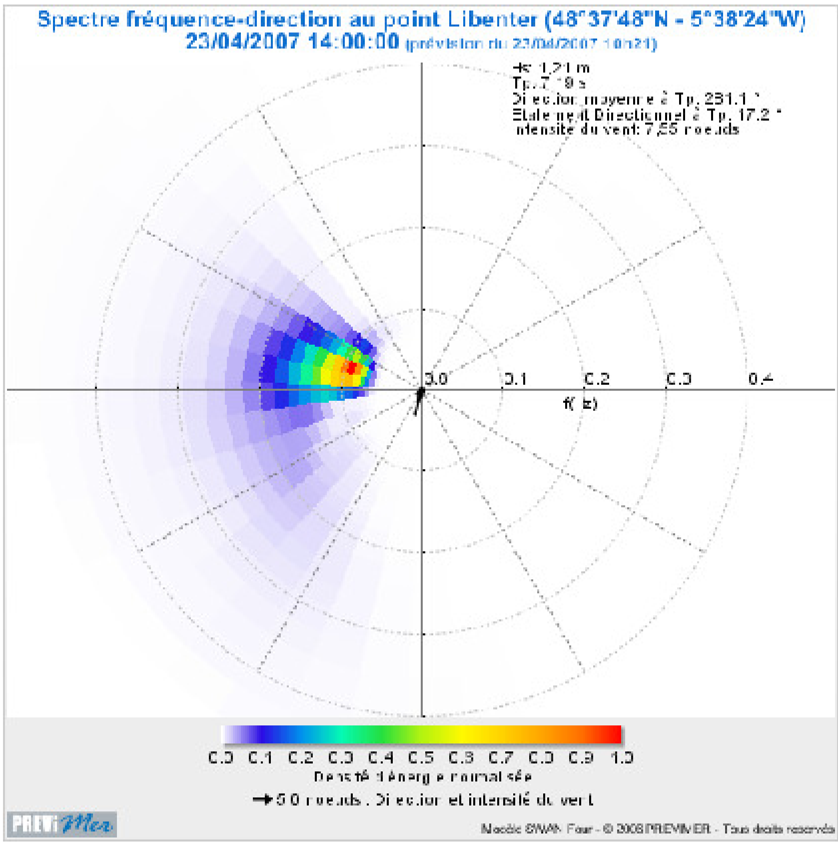
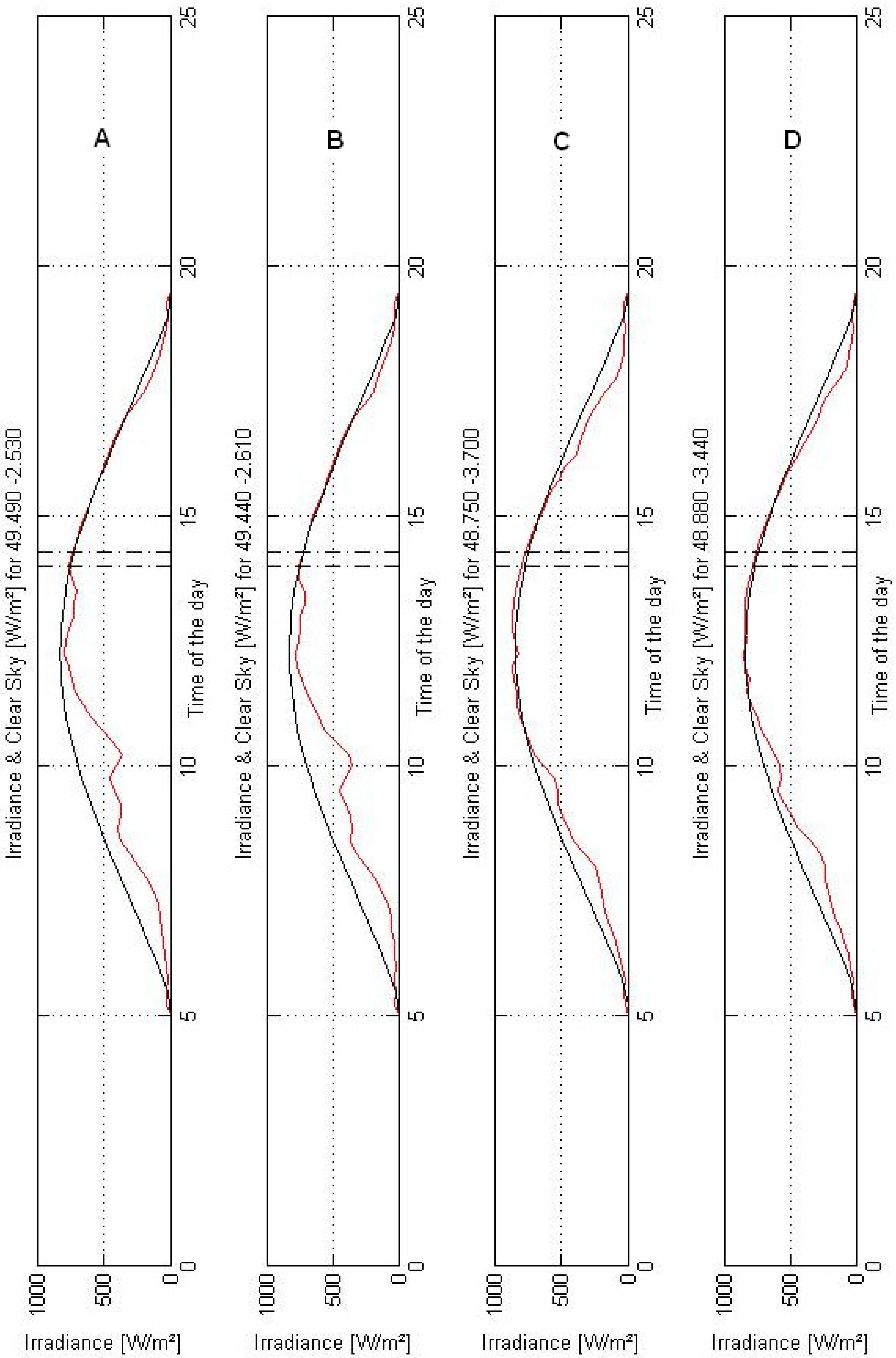


Fig.26 Wave direction-frequency spectrum
recorded by Libenter wave buoy, 1400Z 23 April 2007

[85] Cowley, L., CHANNEL ISLANDS SIGHTINGS: An Investigation into Possible Role of Atmospheric Optical Phenomena, 2007. This excellent 9-page report was kindly prepared for us by Dr Cowley at an early stage in our investigation, and helped greatly to focus the direction of our efforts.



Curves of solar irradiance (red) against clear-sky expectation for 4 locations.
A, north Guernsey; B, south Guernsey; C & D, coastal waters off Brittany.
(Data from Lucien Wald, Helioclim/SODA, Centre Energetique et Procedes Ecole des Mines de Paris, CNRS)

A computer raytrace simulation was produced (*Fig.24*) assuming a 65 km duct (~10°C/100m, producing a -170N/km refractive index gradient) extending from the northern coast of Brittany toward the Channel Islands (highly weakened at this point to ~1°C/100 m), with a 10 km transition toward a standard atmosphere. The *Trislander's* approximate descent slope from the 4000ft to 2000ft flight levels is indicated. Evidently it might be possible with a small adjustment of the parameters to arrange things such that the aircraft passes out of the bottom of the pencil of refracted rays at about 2000ft, resulting in disappearance of the mirage.

A candidate bay was located at Plougasnou, 48.7N, 3.8W (*Fig.25*). This bay, a popular surfing area, lies close to the line of sight to the UAPs.[86] We obtained and graphed (p.69) satellite measurements of solar irradiance on coastal water at two coordinates in this area.[87] In both cases the irradiance was (within uncertainty) the same as the clear-sky expectation of approx 730W/m^2.

We found that this theory does encounter some difficulties. The brilliance of a possible sun-glitter pattern in this area would be sensitive to the wave slope (~20° would be optimum for specular reflection), wave orientation and sun position. Since the sun azimuth is within a few degrees of the line of sight the preferred swell direction for favourable specular reflection would be from the NNE, which does occur in certain weather conditions. But it is not the prevailing wave direction in the Channel. The prevailing direction is from the W. Initial findings about the off-shore wave direction and wave slope on 23 April 2007 were not encouraging.

The Libenter wave buoy located at 48° 37' 48"N, 5° 38' 24"W off the NW tip of Brittany showed the wave direction to be 281° (somewhat north of west) at 1400Z, varying negligibly. A significant wave height of only 1.21m with a period of 7.19sec indicates a slight sea state with a very shallow wave slope of only a degree or two. At 1400Z the Channel Light Vessel at 49° 54' 0" N 2° 54' 0" W (~ 100 km west of ORTAC) measured wave heights of only 0.80m with a period of 8.0sec, indicating wave slopes as small as 0.6°.[88] In other words the wave fronts in the open sea were orthogonal to the required direction for efficient specular reflection (*Fig. 26*) Moreover the sea was very calm, with wave slopes at least an order of magnitude smaller than the 20°optimum for specular reflection.[89]

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[86] It also contains a patch of off-shore rocks which, by interrupting wave trains coming from the NNE and/or masking the specular reflection direction at a low elevation angle, might conceivably also explain a strange "graphite grey band". Realistically, waves would be refracted around it rather than neatly blocked as idealised in *Fig.25*, but Capt Bowyer's report that the edges of the band(s) had an odd "glittering" quality is certainly suggestive of sunlight on the sea. Or maybe these bands were shadows cast by a/c contrails or dense cloud streaks? The shadow of a high contrail can sometimes be seen cast on a lower cloud deck. Viewed from below, the light scattered through the cloud brightens it except in the shadow, which can appear as a quite well-defined dark line. There is evidence of high contrails S of Guernsey on the 1328 MODIS satellite photo (*Section 3*) but these are above high cloud and moreover appear to have dissipated by 1400. It seems scarcely realistic that cloud shadows could be sharp enough (penumbral diffraction) to be prominent against a glitter pattern.

[87] Thanks to Lucien Wald, Helioclim/SODA, Centre Energetique et Procedes Ecole des Mines de Paris, CNRS.

[88] http://www.ndbc.noaa.gov/station_page.php?station=62103

[89] The wave amplitude in the S Channel Islands area itself, measured by wave-rider buoy 6 miles off Corbiere, SW of Jersey, was smaller still (email 23.07.07 Jersey Planning & Environment Dept , Fisheries & Marine Resources):

Time GMT	Sig Wave /m	Period /s	Max Wave /m
13:00	0.67	6.3	1.00
14:00	0.70	6.7	1.28
15:00	0.69	6.9	1.34

All these figures confirm the Channel Islands noon shipping forecast (*Appendix C, Table 3*) of a "smooth or slight" sea state with "insignificant" swell. The Corbiere buoy does not record wave direction.

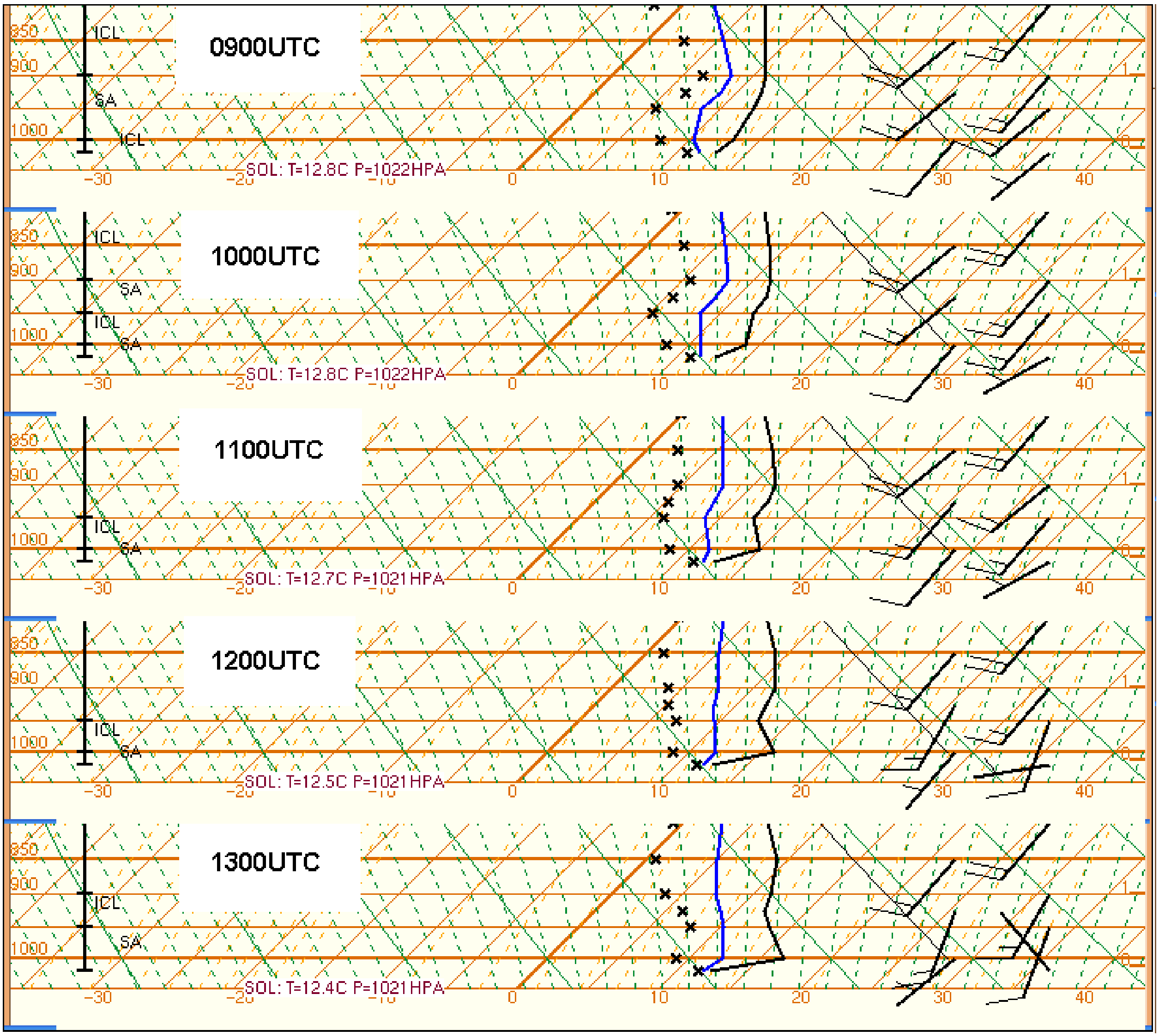

Fig.27 Skew-T plots, surface to 800mbar, Meteo-France ALADIN 4-hour numerical simulation showing dry-bulb temperature (black), dewpoint, frostpoint and winds for location 48.9N 3.4W, 23 April 1300Z. Note surface breeze veering from SW to NW by 1300, before the sighting time.

Shoaling waves encountering shallower water will tend to be refracted towards the shoreline, rotating the wave fronts clockwise in this case; but we had little expectation that this rotation at Plougasnou could reach the ~100° suggested in *Fig.24*, except perhaps very close in-shore. In an area several kilometers off-shore, where the depth will be large compared to the negligible swell amplitude, there could be no refraction. Swell crests would remain near parallel to the line of sight, not perpendicular to it as required.

On the other hand waves are composed of many different frequencies with wavelengths from tens of metres to millimetres, and we learned[90,91] that in any case the brilliant point reflections making up a specular sun glitter pattern come mostly from the tiny capillary waves on the scale of millimetres. We found that some 20° slopes would be produced even by light winds of only 3-4m/sec (~7 knots) recorded in the Channel Islands area. So despite the unfavourable orientation of the underlying gravity waves, if such winds were blowing across the wave crests from the correct SSW direction they might encourage more favourably oriented near-transverse friction capillaries. Surface winds in the area generally were indeed recorded (*Section 5*) as roughly SSW.

But the rms wavelet slope (linearly proportional to wind speed) would be only ~ 4-5°. Could the tail end of the distribution contain enough 20° slopes for efficient sun glitter? We sought expert advice from Bertrand Chapron of the French oceanographic agency IFREMER, who was pessimistic about this theory: The favourable capillary slopes at favourable orientations would be far too few in these conditions and the brilliant point reflections too scattered, leading in his opinion to a low aggregate intensity of reflected light. In short, bright sun glitter from these waters would be unlikely. He advised us to pursue other avenues.[92]

An ALADIN numerical simulation of wind vectors over coastal water was produced for us by Meteo-France (see *Section 5*). The 4-hour animation (*Fig.27*) shows the *surface* wind rotating clockwise and weakening, until by 1300Z it is a 1 - 2 knot breeze blowing from the NW, aligned with the swell direction and *across* the LOS. The likelihood of significant coastal sun-glitter in these conditions seemed negligible. However records of coastal winds at Ploumanach[93] indicate a continuing sea-breeze development which may have produced a N-NE surface breeze by the sighting time, and thus more favourable transverse capillary crests, but speeds of ~1-2m/sec (gust max. 3m/sec) remain low (given an adverse gravity wave vector) for the desired wave slope.

Even a poor slope distribution might be acceptable if we are prepared to consider speculative processes. Raman brightening is one possibility, a rare interference phenomenon due to ray-crossing that amplifies the flux density in a narrow layer at the top of an optical duct. Although the Raman effect is very sensitive to tiny changes in the viewing angle relative to the top of the duct and it seems unlikely that it could persist through many minutes of flight with a change of altitude of >2000ft, conceivably there could be other related rare focusing effects in the duct that might concentrate the luminous flux in a narrow band. But even then, problems remain.

In standard theory, the critical viewing angle for all atmospheric optical refraction effects, whether true mirage or not, is small - less critical than the angle-sensitivity of microscopic interference effects like Raman brightening, but already a serious constraint. Mirages are usually seen through a narrow height range of a few meters or at most a few tens of meters for a very strong inversion. In this case the need to maintain a small angle for many minutes during flight

[90] C. Cox & W. Munk, *Slopes of the Sea Surface Deduced from Sun Glitter*, Bulletin of the Scripps Institute of Oceanography, Vol. 6., #9, 1956, pp 401-88; various emails to J-F Baure and Martin Shough from Andrew T Young (atmospheric scientist, San Diego State U) 28.08.07 - 01.09.07.
[91] N. Ebuchi and S. Kizu, *Probability distribution of surface wave slope derived using Sun glitter images from geostationary meteorological satellite and surface vector winds from scatterometers*, J. Oceanography 58, 477 (2002); L. C. Bobb, G. Ferguson, and M. Rankin, *Capillary wave measurements*, Applied Optics 18, 1167 (1979)
[92] Emails to J-F.Baure from Bertrand Chapron, IFREMER, Brest, 10.09.07 & 11.09.07
[93] http://climatheque.meteo.fr/okapi/accueil/okapiWeb/index.jsp

for tens of miles and through an altitude change of about 2000 ft puts a strain on any optical theory,[94] and this is only increased by the requirement that it rather accurately simulate aspects of the sighting geometry of a physical object in local space:

Between 1406 and 1418 the angular sizes of both UAPs grew larger. The estimated angular width of UAP#1 increased from ~0.5° to ~1.25°, corresponding to an enlargement factor of between 2.14 and 3.0 between the initial and final sightings. We have shown (*Section 3*) that the mean of these values (2.6) is very close to the ratio (2.8) of the two ranges from the aircraft to the triangulated position of UAP#1 near Alderney at these times. But the expected enlargement ratio of features near the Breton coast, about 6 times as distant, would be only about 1.3.

The motions of the images are also very difficult for an optical theory. In *Section 3* we saw that the reconstructed sighting geometry shows a 10° westward rotation of the LOS to UAP#1 not accounted for by rotation of the aircraft's frame of reference during the turn towards Alderney. If real this would rule out a simple mirage theory. This is not a strong piece of primary evidence inasmuch as it could be that a quantitative witness error in estimating relative bearings is causing an error in the reconstruction; but the reconstruction (*Fig.7*) locks in, in a self-consistent way, other angular motions that are strong, non-negotiable features.

The observed azimuth separation of two identical images - whether these be images of source and mirage, or images of a common unseen source miraged twice - has no conventional atmospheric refractive mechanism. And critically, a steady *horizontal motion* of these two images *relative to one another* through an arc of several degrees is even more difficult to explain. Lateral refraction of light rays of more than a few seconds of arc (order of 10^{-3} smaller than reported) is regarded as physically impossible.[95] This is a displacement smaller than the smallest angular distance resolvable by the human eye.[96] Moreover, any tiny lateral refractions that might occur due to horizontal thermal fluctuations (not stable gradients) cannot explain lateral displacements, howsoever small, persisting for many minutes.

And finally of course this theory is of no help in explaining the observation of the yellow/beige oval by the Jetstream pilot, at a near-reciprocal bearing.

Plausibility (0-5): 2

iii) mirage of sun glitter reflections from lakes in Brittany

In a variation on the above theme, we looked for other sources of bright sun reflection and found a pair of adjacent lakes in the hilly Monts d'Arrée region along the spine of Brittany, Lac Drennec and Lac Brennilis, at 155m (500ft) and 225m (740ft) respectively. The latter seemed to be divided by a promontory in a position that might even help explain a "dark band". The larger lake, 3.9km long, would subtend something approaching 1.0° of arc from the 225km (123nmi)

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[94] Email to J-F Baure from Andrew T Young, San Diego U., 28.08.07

[95] In the free atmosphere. So-called "lateral mirage" occurring next to a sun-heated wall or similar is a special case.

[96] The two distinct objects were "very plain to see . . . without binoculars". They were also observed with binoculars, but maximum lateral mirage displacement would still be an order of magnitude smaller than the angle resolvable with 10-power optics, and by contrast the 10x magnified image separation reported would be equivalent to a naked-eye angle of about 20°.

distance of ORTAC, in the right range for the angular size of UAP#1.

Problems here begin with the fact that specular reflection from favourably oriented wave surfaces would again be required. (The bearing of Lac Brennilis from the Trislander, 220°, would be up to ~7° away from the sun azimuth.) Significant ocean swells are obviously not a factor in this case, so the local wind friction is the only available generator of wave slopes. Interpolating between the nearest height readings of the Brest radiosonde (noon ascent), winds were 222°, 12 knots. The direction is favourable. As was the case with the Plougasnou sea bay scenario we are not sure that a ~10 knot breeze is sufficient to generate enough 20° capillary wavelet slopes. Being a small lake there is no adverse ocean swell orientation, but at the same time the wind fetch is very short and the lake is sheltered by hills on the windward side.

Fig.28. Lines of sight to Lakes Drennec and Brenillis, Brittany, possible candidates for miraged sun glint reflections (Google Earth image).

A more serious problem is that the terrain in front of the lakes is also elevated. Lac Brennilis at 225m has a ridge of terrain rising to >300m within 3nmi on the line of sight, and its little sister, Lac Drennec,at 155m, has 200m terrain within 2-3nmi. For the more interesting Lac Brennilis this represents about a 0.8° obstruction, and even assuming a flat earth the elevation angle to the Trislander at ORTAC (3460ft above datum) would be only about 0.25deg. The ray bending required to refract light from the lake surface over this terrain seemed extreme, and the situation would be worse when the plane is down near 2000ft towards the end of the sighting.

We explored this by plotting elevation angles over a digital elevation model of the Monts d'Arree topography. We found that reflections from Brenillis below 0.6° - 0.8° would indeed be masked by the hills and that the situation was even worse for Lac Drennec, which would be entirely masked below 1.1°. With such steep reflection angles, the reflected rays would reach the coast 60km away at more than 3000' ASL in a standard atmosphere, and yet observers descending to 2000ft a further 135km (74nmi) away were able to see the UAPs. The requirement is for a very strong and deep optical duct rising to perhaps 600m (~2000ft) or more, contributing a ray curvature several times the earth-radius trapping value of 33”/km in a short distance, in order for the rays to be refracted earthward before being released by the duct at a point still far enough from the Trislander to be observed (as variously described; *Appendix B*) “against the sea”, “coming from the sea”, “against the sea and the land [Guernsey]” or at a depression angle approaching “2 degrees” below the horizontal.[97]

So the lake hypothesis requires a temperature gradient several times the +11.6°C/100m optical trapping gradient. But meteorological evidence, including the Meteo-France numerical simulation of the temperature profile over the Breton coast, shows no sign of any elevated inversion at all, and there appears to be no mechanism that could produce such an extremely strong trapping layer (*Section 5*). The only inversion for which there is meteorological evidence is a marginally-ducting surface layer capped at 200m above the sea, whose boundary is 100m below the level of the hills that mask Lac Brenillis from the observers, and indeed below the level of the lake itself. No light rays from the lake surface could even couple into this duct.

To summarise some problems with this theory: Very unrealistic temperature gradients are required for which there is no evidence; capillary slopes favourable for specular reflection on the lake are far from certain; no mechanism exists for the duplication of *laterally* separated images with the *same internal detail*; no explanation exists of the lateral *rotation* of the two LOSs relative to one another; the change in angular size of the distant lake during the sighting would be

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[97] Email to Martin Shough from Andrew Young, San Diego U., 01.09.07: The local elevation of the ray as it exits the duct can be no more than a few minutes of arc. In order for this ray to reach the observer at a depression angle of 2°, the observer's astronomical horizon must make an angle of about 2° with the horizon at the point where the ray leaves the duct. In other words the observer has to be nearly 2° of a great circle on Earth away from the end of the duct, or about 120nmi. The total distance from the initial sighting point NNE of ORTAC to the lake is about 132nmi, which would allow only ~12nmi (22km) path length both for coupling into the duct and for propagation within the duct. A refraction of 2° in this distance implies ray bending >10 times as severe as an optical trap and a temperature gradient proportionately steep.
However the situation is worse than this, because the estimated elevation angle to the UAPs (appearing nearby and co-altitudinal with the Trislander‘s FL40) was initially near 0° and the depression angle only *increased towards the estimated 2°* (“against the sea and the land”, Capt Bowyer) *just before descent,* when the aircraft was within ~113nmi of the lake. (Immediately after the start of descent Kate Russell confirmed the impression that UAP#1 appeared to be “coming from the sea). Clearly there is now *no* distance (actually, a *negative* distance) available for propagation within the duct.
We can try to resolve this by reducing the required depression angle. If we halve the angle to 1° below the horizon we still have only 53nmi (97km) available for coupling into, and for propagation within, the duct. An 11.6°C/100m trapping gradient produces about 53arcmin refraction in that total distance. But we only get the benefit of that refraction if light rays near 0° elevation are available from the source in the first place. In this case most of the first 53arcmin of refraction is cancelled out because the minimum angle of reflection for masked rays coming from the lake is already greater than about +40arcmin. So in practice we have only in the order of -10arcmin depression in the first 53nmi (6”/km) for a trapping gradient, which means that even a visual depression angle as small as ~0.5 degree (¼ of that estimated) requires about twice the refractivity due to a 33”/km duct and thus well over 20°C/100m of temperature inversion, which is completely unsupportable.

fractional and could not approach the factor 2.6 observed; and the object observed from the Jetstream on a near-reciprocal sightline would be an unexplained coincidence.

Plausibility (0-5): 1

iv) reflection from ground objects

At great distance, on mainland Brittany, any such object(s) would have to be in the region of 2nmi (4km) across to subtend the angle observed. Even allowing for a very large error in visual angle estimates, no candidates (apart from the lakes) appear to exist. This leaves us with objects on the island of Guernsey. Realistically the only large reflective objects on Guernsey are the flower and vinery glasshouses. This of course was Capt Bowyer's very first interpretation of UAP#1 because the initial LOS passed approximately across the middle of Guernsey and he had seen specular reflections from the glasshouses before, lasting a few seconds.

Such reflections would not be surprising. Sunshine on Guernsey was abundant (p.69). There are many commercial glasshouses on the island extending in all to 1.539 x $10^6 m^2$ of glass (2.54% of the island area), in addition to many polythene tunnels (map, p.78). They are built in blocks often 4-5,000m^2 in extent or more, such as those of the Guernsey Clematis Nursery in Vale (10,000m^2 and 4,450m^2) and St Sampson's (5,750m^2). The Vale buildings are typical of most of the glasshouses in Guernsey and are of the "Venlo" design (*Fig. 29*). Ridge orientations are very variable. The ridges at Vale all run approximately E-W, the largest block being 200m x 50m.[98]

In this case the Venlo ridge angle of approximately 23° is close to the optimum angle for specular reflection given the elevation of the sun at the time of the observation, and it seems quite plausible that one of the glasshouse blocks might have been oriented so as to direct specular sun reflection towards the Trislander. The expected ratio of angular sizes (1.86) would be closer to the visually estimated ratio (2.6) than was the case for much more distant Breton bays or lakes.

Even a 200m length of glasshouse subtends little more than ~6arcmin from the range of the initial sighting ~52nmi away, and even at closest approach (~28nmi) would subtend only ~12arcmin. Thus there is a factor 5 discrepancy in angular size from the witness estimates of 0.5 - 1.25°. But this need not be a problem if we assume reflections from multiple adjacent blocks, with a non-reflective strip of ground between them perhaps accounting for the "dark band"?

Of more importance is the persistence of the "sharply-defined" images of UAP#1 and UAP#2 for some 12 minutes and 6 minutes respectively, despite changing reflection geometry, remaining identical in appearance during level cruise at 4200ft and during about 2000ft of descent. The motion of the aircraft represents about 0.5° change in elevation (1.2° to 0.75°) relative to a reflector on Guernsey, which is not large. Given a planar reflecting surface we would expect the angle over which specular reflection occurs to be comparable to the angular diameter of the sun (0.5°). The change in bearing required is an order of magnitude larger than the solar diameter, which is more difficult to accommodate, seeming to require a reflector with a radius of curvature rather than a plane reflector like a glass roof.

[98] Emails from Paul Ingrouille, Production Manager, *The Guernsey Clematis Nursery Ltd*, St. Sampsons, Guernsey, to J-F Baure, 06..07.07 & 14.07.07; Dave Killan, Director, *Digimap (Jersey) Ltd* to Paul Fuller, 29.02.08, 06.03.08.

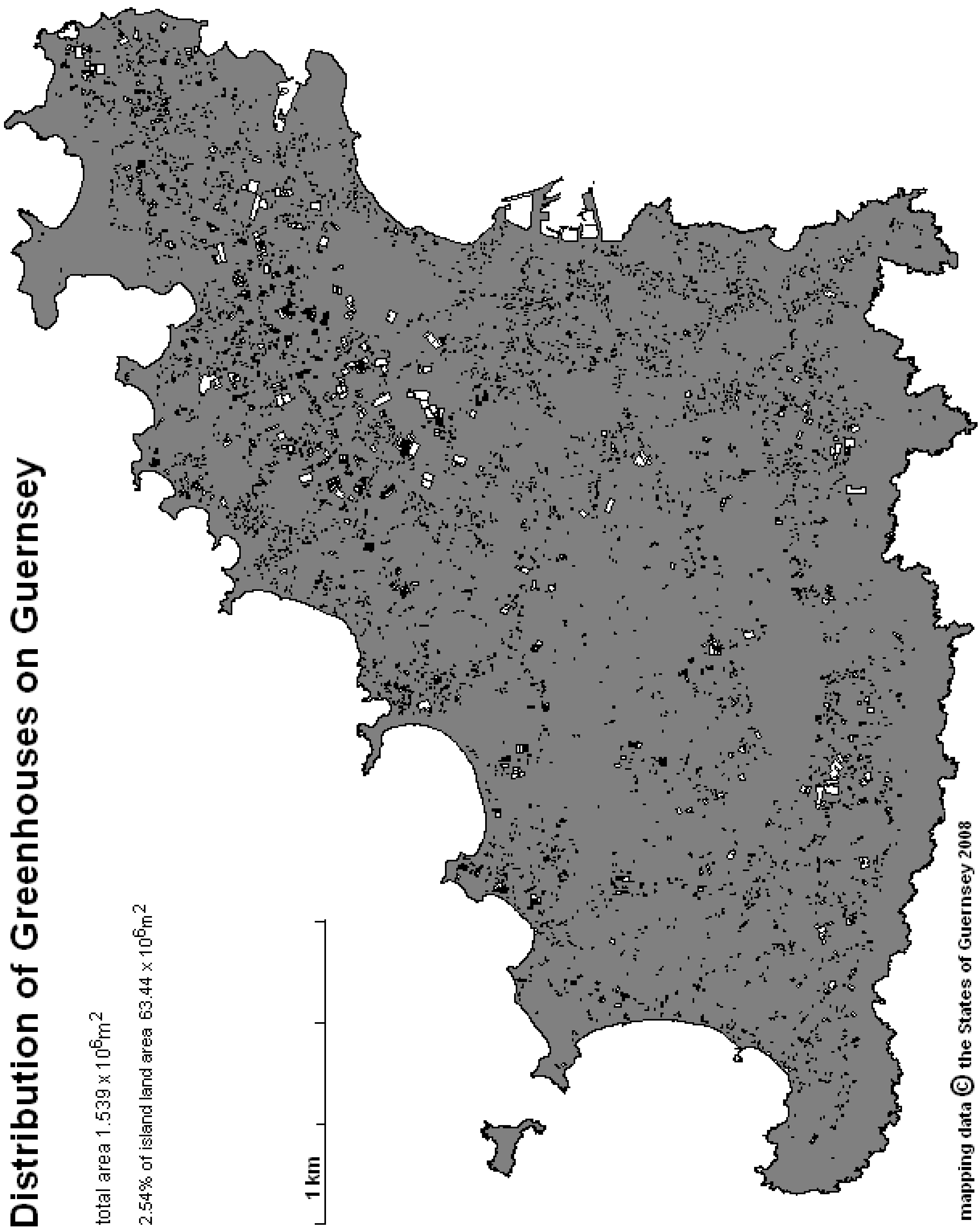
Fig.29. Typical "Venlo" style glasshouse on Guernsey with 2m x 1m glass panes laid to a ridge angle of ~23°. Other "Q22" glasshouses have 75cm panes inclined at ~30° and are built in multiples of a 7m span. (Photo courtesy Paul Ingrouille, Guernsey Clematis Nursery Ltd.)

We note that an observer familiar with specular sun reflections from Guernsey glasshouses, in varying conditions during hundreds of near-identical trips on this airway over the course of 8½ years, rapidly discounted the theory. The "escalation of hypotheses" happened initially because UAP#1 failed to disappear as a reflection normally would. For Capt Bowyer, and for us, the strangeness of that fact was reinforced by these further factors:

First the pointed cigar shape, edge-definition and "dark band" observed through binoculars; secondly, the appearance of the smaller but otherwise identical UAP#2 offset to the west; thirdly, the independent *horizontal* angular motion of these two UAPs by several degrees relative to one another; and finally the impression that the angular *elevation* of the UAPs rose towards zero degrees just before disappearing as the aircraft descended to the 2000ft haze layer.

A distorted mock mirage of Guernsey glasshouse reflections could not explain images observed at changing elevations, varying from a significant depression angle below the horizon ("2 degrees", "against the sea and the land", "on the sea") to near zero degrees at the top of the haze layer as the *Trislander* descended to the haze. We believe that the exit angle from the duct would be tightly constrained to within a few minutes of arc and could not vary in this way.[99] And more importantly no vertical temperature structure can explain a lateral image displacement of several degrees (or indeed 5x lateral magnification) - still less can it explain steady, independent lateral motions of these displaced images.

[99] Email from Andy Young, San Diego U. to Martin Shough 31.08.07. "Ducted rays cannot be inclined to the local horizontal by more than 1.4°, even if the hot air above the inversion has infinite temperature. For likely temperature differences such as the 5° we have been discussing here, the maximum inclination of ducted rays is only a few minutes of arc."



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In any case, according to the Meteo-France computer simulation and consistent expert advice from Channel Islands meteorologists (*Section 5*) a localised duct over the Breton coast has broken down some distance south of the Channel Islands area, leaving only a weak inversion (2-3°C/kft, ~1/10 ducting strength) in the Channel Islands area.

To these problems we can add that the triangulated apparent location of UAP#1 at >1500ft near Alderney was intersected by the reciprocal sightline from Capt Patterson to an unusual yellow object at a similar height in a similar location, which was over the sea, far from Guernsey.

Plausibility (0-5): 2

v) haze scattering, coronal diffraction etc

We considered that the haze layer between 1500-2000ft, possibly marking the top of the weaker local inversion, could have played a part by scattering reflected light. The light intensity scattered by aerosol particles is sensitive to the angle of incidence and the droplet size. We had ignored scattering by the haze layer when considering sun rays reflected from the sea or lakes, since in these cases most of the rays would be incident on the layer at a large fraction of the ~45° elevation of the sun (relatively few specular glint points from capillaries would be directed at a shallow angle near 0°, we found), and in these circumstances the forward scattered intensity near 0° would be very weak, regardless of the droplet size. But reflected sunrays from a glasshouse roof with a shallow 23° pitch would be incident on the underside of the layer at a grazing angle, and the forward-scattered intensity could then be relatively strong. Possible effects could be to soften and enlarge the light source (Capt Bowyer did report that the UAPs, although brilliant, were neither "dazzling" nor "tiring to the eye"), and/or to produce a diffraction corona.

One immediate difficulty is that under binocular observation the UAPs appeared "very sharply defined" at the edges. Diffusion by a scattering layer ought to spread and soften the specular reflection, not sharpen it. Perhaps a sufficiently bright area of light might appear sharply defined by overloading the retina, thus making a flat field that has a sharp cut-off. But that effect would define a "dazzling" or "tiring" image, contrary to what was reported. Capt Bowyer noted that the UAPs were not intense enough to cause noticeable afterimages, even when using binoculars.

We then have to deal with the fact that two UAPs were observed, identical in every respect except angular size and angular position/motion. One possibility is two distinct haze levels, illuminated by light rays scattered almost in the direction of the observer from a single terrestrial source. A narrow pencil of specular light rays behaving like an inverted "god ray" could intercept the lower layer first, with some light being scattered out of the beam to cause the smaller and more distant bright patch. Enough light might still be transmitted to the higher layer to create a nearer and larger patch slightly to one side as viewed from the *Trislander*. The relative lateral motion could then be explained in a very natural way in terms of parallax: Over time the separation reduces. When the plane's course intercepts the angle of reflection the two spots coincide and finally cross one another.

A simpler variant on this scenario would explain the small UAP#2 as the source itself, source of a beam of specularly reflected light visible directly by off-axis rays falling a degree or two outside the narrow cone of brightest reflection, whilst the cone of brightest reflection intercepts a fairly thin haze layer below the aircraft at 2000ft causing a larger offset patch of scattered light visible in the position of UAP#1. UAP#2 appeared initially a degree or two to the W of UAP#1, nearer to the sun azimuth, suggesting a pencil of sunrays reflected forward at a few degrees elevation from a Venlo roof ridge oriented approximately E-W and intercepting a haze layer a degree or two to the E (left) of the source as viewed initially from the *Trislander*.

One merit of the theory is that it offers a possible explanation of Capt Patterson's sighting from the Jetstream. A pencil of strong sunrays intercepting the haze layer would scatter to some extent in all directions. It might well be the case that whilst the most efficient scatter occurs near the forward direction, sufficient photons are backscattered (even a few percent of a bright light source might be sufficient[100]) to be visible from the south as a patch of light in the triangulated position of UAP#1.

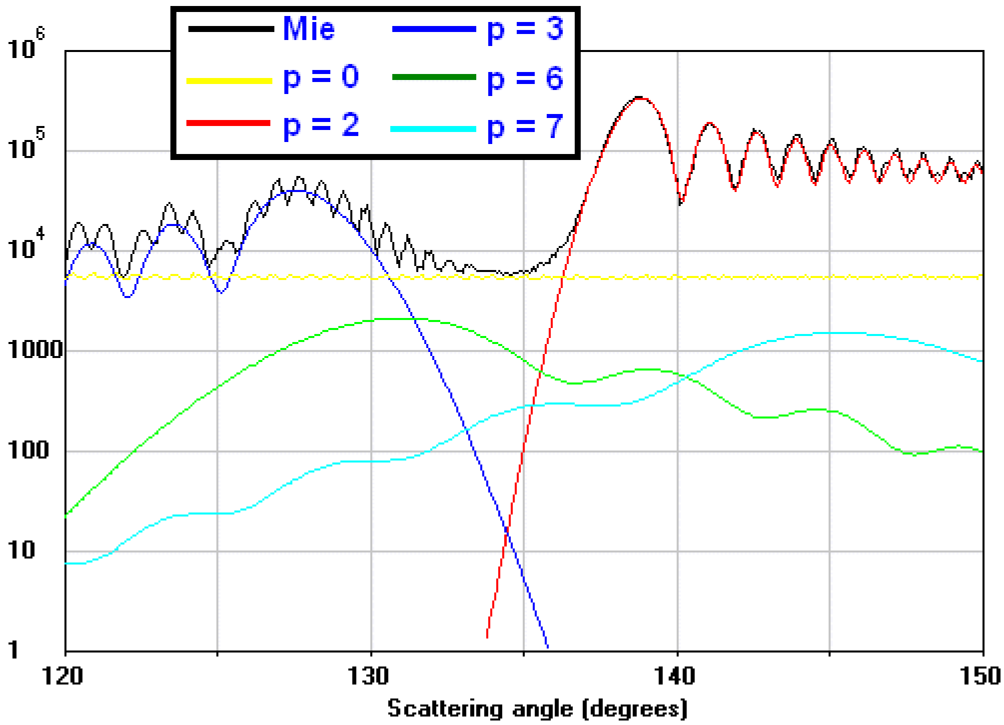

Fig.30. Mie plot of 0.65 micron light scattered by a 100 micron droplet, showing all scattering processes (produced by MiePlot, courtesy Philip Laven)

The exact result is very sensitive to the size and nature of the particles, but the components of the overall Mie scattering solution typically sum to a secondary scattering maximum at 180°, composed of different back-scattering peaks at smaller angles due to different scattering processes. For example the graph in *Fig.30* (produced by the Mieplot programme written by Philip Laven[101]) shows the phase dependence of scattering from 100micron droplets, where it is noticeable that the first and major backscattering mode, p=2 (red curve, one internal reflection, which is the same path responsible for primary rainbows), becomes significant at angles greater than about 140° with order-of-magnitude fluctuations damping towards 180°. (100micron is

[100] Thayer, G. D., "Light Scattering by Aerosol Particles", Gilmor (ed), *Scientific Study of Unidentified Flying Objects (Condon Report)*, Vision Press, 1970, pp.646-650. http://www.ncas.org/condon/text/s6chap04.htm
[101] http://www.philiplaven.com/index1.html

probably large, but indicative).

This type of effect could fit our triangulated position of UAP#1 (*Fig 7*). Initially at ~1413 Capt Patterson is unable to see anything in the indicated area. He is at this time around 160° of bearing from the hypothetical incidence angle, and also only about 12.5nmi from the hypothetical location at ~6500ft, therefore ~4500ft above the haze, viewing the scattering volume at a depression angle of ~3.5°. By 1414:43 when he reports visual contact he is 17.5nmi away and down to ~4000ft, nearer the haze and now viewing the scattering volume from ~140° at a depression angle of only ~1.1° and reducing. It seems possible that the complicated changing relationship between the *Jetstream's* course and the peaks and nulls in the phase diagram, which would occur as family of cones centred on the axis of specular reflection, could cause a patch of light to appear only intermittently. But when we calculate visual elevation angles from the *Trislander*[102] this model does not work so well.

We find that from the position of the *first* sighting at 1406Z a source on Guernsey and a UAP#1 haze patch at 2000ft would both be at a depression angle of ~1.0°. Conceivably azimuth angle might also coincide, in which case the source (UAP#2) could be located directly in line of sight behind UAP#1. This common LOS would by definition lie along the peak intensity of the reflection. Changing parallax during approach could cause the source to emerge into direct view, its secondary image becoming intrinsically dimmer (as the viewing LOS leaves the angle of most intense reflection), but at the same time growing larger, as the flux per unit angular area increases like the inverse square of reducing distance to the scattering volume. We can perhaps thus explain why UAP#2 is not seen until later and why UAP#1 remains bright when viewed off-axis.

But we cannot explain why UAP#2 then appeared *above* UAP#1 (*see Fig.4 & Appendix B*). It would appear at all times below it, and by the time of the last sighting at 1418Z we find that whilst the nearer, projected, image (*ex hypothesi,* UAP#1) would appear at a depression angle of about -0.2°, the source on Guernsey (the smaller UAP#2) would be at about -0.7°, or 0.5° *below* UAP#1. This is the opposite of the behaviour observed.[103]

By reducing the altitude of the haze layer to about 1200ft we can reduce the expected visual elevation of UAP#1 towards coincidence with UAP#2; but we find that it remains impossible to get UAP#1 to appear *below* UAP#2 as reported without dropping the haze scattering volume to as little as ~600ft. This is probably not consistent either with observations or with meteorology. And we have introduced the further problem of explaining the visual identity under binocular inspection (in terms of detailed form, sharpness and brilliance) of a direct specular reflection and

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102 Using a flat-earth approximation here as the largest distances are only about 60% of the earth horizon distance and it is the relative elevations that interest us.

103 Might an additional mirage have inverted and transposed (inferior inversion) the images of source and haze projection? This implies ray-crossing (due to the gradient of refractive index being much greater in the lower part of a mirage layer) in the ~12-21nmi between the location of the UAP#1 haze patch and the *Trislander*. But for this ray-crossing to invert the two images we need a *differential* refraction equal to (~0.5° + the observed vertical separation of ~0.3°) = 0.8°. This *difference* in refractivities over the two paths is obviously the minimum true abnormal refractivity produced: Unless the abnormal refractivity on one of the two adjacent paths is zero (which is not physically realistic), the true maximum refractivity of the required layer must be significantly *greater* than this, i.e., >>1.0° at the observer. In 12nmi (22km) with a trapping gradient of 33"/km we can get a total refraction of 12arcmin. So we certainly need >5 times the refraction produced by a strong (trapping) optical duct of 33"/km between Guernsey and the *Trislander*. There is no meteorological case whatever for such an extraordinary atmosphere.

of its secondary reflection in a far-off patch of haze. This seems unrealistic.

So we adopt the more complicated hypothesis of two separate co-altitudinal haze images caused by an unseen source or sources of reflection. In this case we can get the more distant and angularly smaller UAP#2 to stay above UAP#1 as observed (without unphysical refractive index gradients), and we can still possibly account for the early lack of detection of UAP#2 because although the difference in elevation angle is not zero, it is small, in the order of 0.1°. Conceivably the brightness of the larger and brighter UAP#1 swamped the adjacent UAP#2, and magnetised attention, until the vertical separation angle grew during approach by a factor 4 to ~0.4° at ~1413.

But this raises other questions: What is the chance that two different sources (themselves unseen even though *ex hypothesi* close to the line of sight[104]) simultaneously satisfy, for the same observer, and persistently, the conditions of what must be a rare (never-before seen) reflection geometry? What is the likelihood that these sources would both produce scattered light patches of identical narrow "cigar" shape? Conceivably the two pencils of near-collimated specular rays strike a scattering layer that is physically very thin, so that any arbitrary area of illumination viewed at a shallow angle will tend to look long and narrow. But even so, how could we explain that both images display an identical "graphite grey" vertical band in the corresponding position?

One other factor we considered in the haze-scattering scenario was coronal diffraction. Sunrays specularly reflected at a low angle into haze will be diffracted through a small scattering angle depending on the droplet size. This angle needs to be large enough to explain the persistence of the "brilliant" UAPs through rotation of the observers' LOS. The rotation due solely to the radar-plotted motion of the *Trislander* is as much as 10° in relation to the forward-scattering haze location of UAP#1.[105] Could a corona remain "brilliant" through such a large scattering angle?

This is by no means certain. Typical ratios of intensity between the peak forward scattering lobe at 0° and the first null in the diffraction pattern can be two, three or even four orders of magnitude, and the first sidelobe can be about an order of magnitude below the peak. The angle to the first sidelobe will be inversely proportional to the droplet/particle size, so we can choose a small droplet to widen the angle of the peak lobe.[106] Diameters in the order 100micron produce a bright, narrow peak lobe near 0°, but they are likely too large to remain in a suspended haze of this type. A 10 micron droplet produces a peak lobe of about 1° radius, a first null at about 2° and a coronal lobe at about 3°, which is heading in the right direction. A 5micron droplet increases the radius of the first null to beyond about 4°, and can begin to accommodate the necessary LOS rotation. But at the same time the scattered intensity is inversely proportional to the scattering angle, and at 5micron is now relatively very weak. Given the inherent inefficiency of the off-axis viewing conditions required and the thin haze (having insufficient opacity to obscure the island

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[104] We previously considered a single pencil of sun rays reflected from a single source and intercepting two stacked haze layers in succession - one absent source would certainly be easier to explain than two. But then it is not possible for the two UAPs to be co-altitudinal. They are aligned on the same optical axis originating on Guernsey, with the same problem of relative elevation that we sought to avoid by making them co-altitudinal in the first place: UAP#2 can once again not appear consistently above UAP#2 as observed unless the two physically separate haze layers are so close together, and/or at such low altitude, as to conflict both with observation and with meteorological reasonableness.

[105] 5° in relation to an unseen source (*ex hypothesi*) on Guernsey.

[106] Scattering profiles can be modelled using MiePlot v3501.exe (http://www.philiplaven.com/mieplot.htm), IRIS (http://www.atoptics.com) or similar applications

of Guernsey) one is bound to wonder if this mechanism is capable of delivering the near-specular brilliance of the images observed.

But if coronal diffraction does play a part it is natural to wonder if the "dark bands" could be explained by nulls in a diffraction annulus around a brilliant source. In this case we are making different demands of the droplet size. The 5micron aerosol with its first coronal null at ~4° is of no use for this purpose since the angular width of the UAP images was generally smaller than about 1° with the dark bands in the order 0.1°, so with a 5micron haze the null itself would be a soft gradation comparable in width to the entire image. With a larger droplet we can produce a sharper and thinner null. *Fig.31* below illustrates the position of the first null in a 70 micron corona.

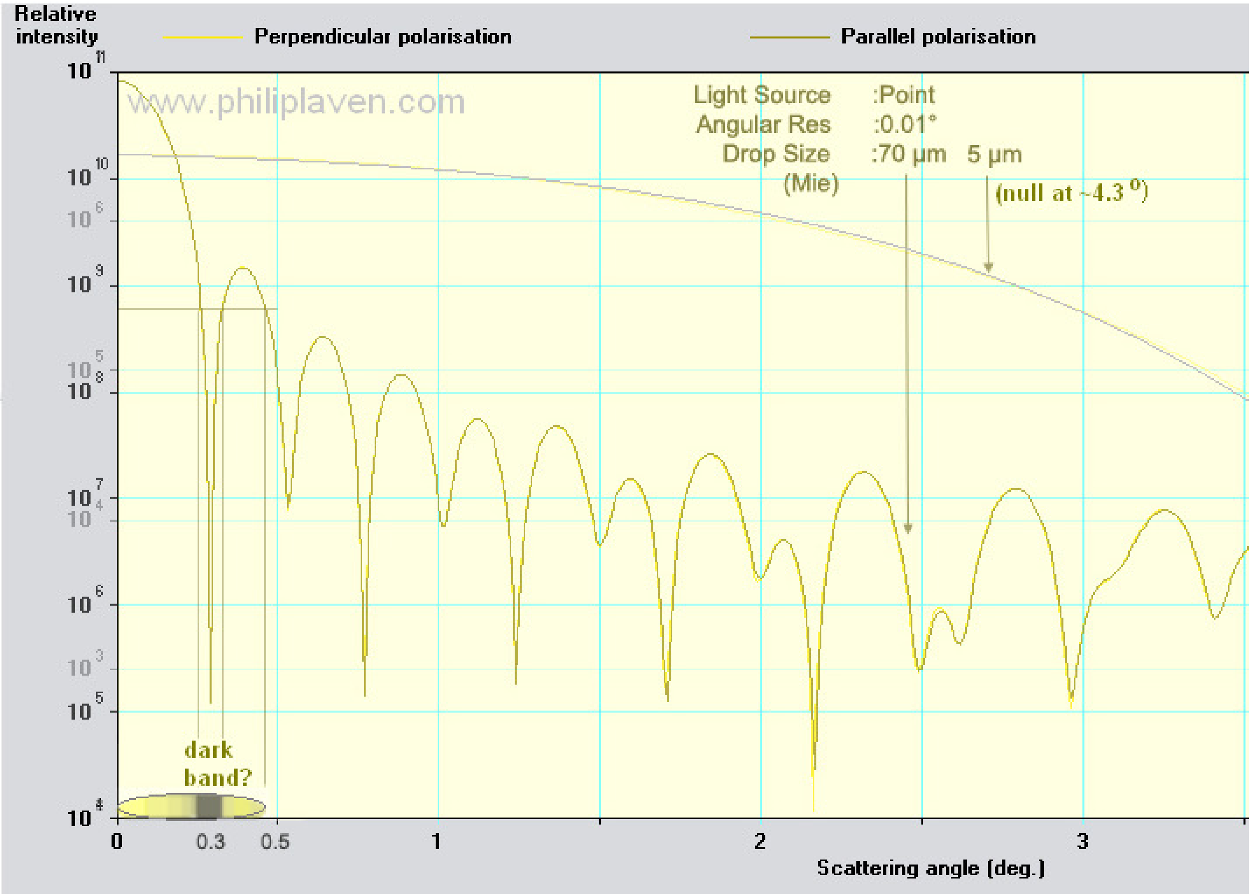

Fig.31. Scattering angle against intensity for 70micron droplets illustrating a possible explanation of the "dark bands" observed on the UAPs . 5micron curve shown for comparison. (MiePlot.exe application from www.philplaven.com)

But this theory implies some very fortuitous selection. The reflected rays would just happen to be intercepted by an isolated patch of haze slightly offset from the optical axis in such a way as to select one thin segment from the right hand side the first annular null, so that it appears 2/3 of the way along the sliver of corona. What is the probability that this happenstance occurs twice with two quite separate coronae produced by two separate patches of haze? If it is reasonable for a haze of this kind to contain droplets sufficiently large to produce a sufficiently sharp corona pattern,[107] this large-droplet requirement is in any case again in tension with the requirement for a broad scattering angle. Note also that the ratio of lobe brightnesses approaches 100:1, and it is not clear that a small, relatively very dim lobe to the right of the null would answer the witness description. A related point to bear in mind is that Capt Bowyer insists, several times, on the "very sharply defined" binocular outlines of both UAPs.

It has been suggested to us that the “dark bands” resemble spectral Fraunhoffer lines. But the only reason spectral lines are called "lines" is because spectra are made to appear in this shape by the way prism spectrographs are made, i.e. the light enters through a narrow slit. In other words the regularity of separated "lines in a spectrum" is an artefact of the instrument and could not occur in this case.[108]

In summary, certain features of the haze-scattering theory are attractive. Given narrow sunbeams from sources of specular reflection on Guernsey we can locate two separate luminous phenomena (two scattering regions of the haze layer) at altitude over the sea in approximately the areas apparently triangulated by observation. And unlike mirage refraction theories this can possibly explain the relative horizontal angular motions of the UAPs in terms of parallax. It is also possible in principle that some backscattered light from the same scattering volume could explain the fainter patch of colour sighted in the triangulated location of UAP#1 by the *Jetstream* pilot from the south (UAP#2 being of course some miles further SW and out of his field of view).

But other features - the brilliance/persistence; the edge sharpness; the duplicated identical shape, including detail of “graphite grey” bands, occurring (*ex hypothesi*) in two locations miles apart - these are not easily explainable by scattering of glasshouse reflections from a haze layer. We also take note of the fact that no phenomenon even similar to this has been seen before by Capt Bowyer in 8½ years and hundreds of flights on this same airway in all conditions .

Plausibility (0-5): 3

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107 Dry haze nuclei (salts, dust, pollen etc.) are typically much smaller particles, <1.0micron. In conditions of high relative humidity they expand by deliquescence and the optical thickness rises appreciably. The resulting droplets can be of arbitrary size, becoming mist, fog, cloud or precipitation. The reports in this case indicate “not a salt haze”. Capt Bowyer described it as caused by “bad air from the continent”, indicating perhaps a mix of petrochemical (ozone, nitrous oxides and hydrocarbon) smog, dusts and pollens, which swell less than salt nuclei. The air at the haze level appears very dry (*Section 5* & *Appendix D*). A small droplet size is suggested, which could fit a scattering theory by removing the blue wavelengths and yellowing transmitted sunlight to the “yellow” and even “orange” hues reported. However a fine droplet size would produce far too large a corona for our purposes.

108 In nature the equivalent instrument is usually an individual droplet and if you examined its spectrum closely enough you could see Fraunhoffer absorption bands - though they wouldn't look like "lines" across a linear spectrum. In the case of our UAPs the "instrument" would have to produce a symmetry whose axis is linear horizontal in order to separate spectral wavelengths laterally and display a vertical "absorption line". Diffraction is a similar case. If you have a diffraction grating you can get regular lines from a line-shaped light source by orienting the regular grating correctly, but generally because there is no slit it only works with point-like sources and then you get diffraction spectra with 90° rotational symmetry. But diffraction by a random ensemble of cloud particles or the like could not produce any ordered linear symmetry, instead you would get the superimposed chaotic diffraction products of a billion different particles. Small randomly oriented variations in RI cause continual wander of raypaths in turbulent air and this causes scintillation, but again the distribution of RI is randomly chaotic about the line of sight. Also, the colouration in this case is described as a flat field, much like the mixed solar spectrum. No evidence of separated wavelengths. Absorption bands are very narrow in relation even to the separated colour bands within which they lie.

e) aircraft contrails

A section of brightly sunlit contrail might appear strange in certain conditions - for example if broken cloud produces unusual contrasts of light and shade - and could resemble a distant bright cigar shape lying parallel to the horizon. The high resolution 1328Z MODIS image (*Fig.19*) shows several contrails above the clouds. Note their shadows on the cloud deck: If a higher contrail happened to be oriented so as to cast a shadow across a lower this could possibly also explain a "dark band".

Jet contrails are of two types. High altitude exhaust contrails as in *Fig 19*, which are formed of ice crystals nucleating around exhaust particulates at atmospheric temperatures far below zero (around -40°C), and aerodynamic fog contrails at low level. The latter may occur around aircraft surfaces in humid air when moisture condenses due to a local pressure drop caused by the aerodynamic lift.

The line of sight to the UAPs from both aircraft (Aurigny *Trislander* to the north and Blue Islands *Jetstream* to the south) was close to the horizon or even at a small depression angle. UAP#1 was observed from the *Trislander* "against the sea and the island [Guernsey]". These factors would all indicate local contrails - i.e, located approximately where the triangulated lines of sight intersect in *Fig*.7 - and at an altitude significantly lower than ~4000ft. This is >6000ft below the freezing level and 20,000ft below typical exhaust contrail heights, requiring pressure-caused water droplet contrails. But since the pressure change is local to the wing it is transient and such trails would not normally persist for many minutes after the passage of the aircraft, which gives added emphasis to the question of what jet(s) might have been responsible? Very dense and persistent highly-reflective low-level contrails would be unusual and ought also to have been visible to other aircraft asked to look out for anything in the area. Nothing was seen by the BAe146 flying above the immediate area.

Civil traffic during the sighting time was not in the right area. The FlyeBe 146 did not even taken off until some minutes after the start of the sighting and the *Jetstream* was still 25-30nmi W of the line of sight to the UAP. No unusual aircraft activity was reported by these or other aircrews. The Channel Islands Zone and Jersey Approach radio recordings from 1406:47 contain no reference to unusual traffic prior to Capt Bowyer's first radio contact at 1409:32. During this time SVW 23 AR is handed off to Jersey Approach at FL60, an Aurigny island-hopper approaches Jersey, Thomson 742B leaving the Control Zone to the south is instructed to contact Brest, and N9MS leaving the Control Zone to the north and crossing 50°N at FL70 is instructed to "continue VFR and contact Plymouth military". This is because the area NW of the Control Zone is a designated military exercise area, but ATC advises "no known traffic" in the area. These are clearly all routine commercial flights. Unidentified military jets crossing civil air lanes inside the Control Zone at ~2000ft without ATC clearance and/or the prior issuing of NOTAMS[109] seem most unlikely. Inquiries were made to the UK MoD in respect of any military exercises carried out in the Channel area on 23 April. The MoD responded as follows:

[109] NOTAMs (Notices to Airmen) are hazard warnings required under an international ICAO convention. They are distributed electronically to aviation and navigation service providers. Military exercises and the like require NOTAMs. None were issued.

> The MoD did not conduct any military exercises (naval, RAF or army) in the English Channel, nor is it aware of any known military activity involving other nations (e.g. France) on or about Monday 23 April 2007.

Also relevant to the possibility of low-altitude contrails is the humidity at the hypothetical altitude, which would be about 2000ft. The closer the relative humidity is to saturation (RH = 100%) or supersaturation (>100%) then generally speaking the more likely is condensation to occur with a given aerodynamic reduction in pressure and temperature. Since the pressure change will tend to be proportional to aircraft performance and acceleration, the RH clearly relates to the likelihood of aerodynamic fog being produced by light commercial traffic.

A reported haze layer close to 2000ft altitude is believed (see *Section 5*) to be a particulate haze intruded from the continent.[110] The noon Brest radiosonde ascent shows RH at 52% at the surface and <40% through the first 3000ft, which is quite dry, falling to an unusually dry 10% at about 2000ft. At the sighting time, Guernsey surface RH was recorded at 59% (17°T, 9°D, well below the local 22-year historical April average[111] of 73%), and Alderney surface RH at 77% (14°T, 10°D). The mean of these values is 68%. This tentative evidence on the whole does not suggest saturation in the lower atmosphere, although an elevated humid layer isn't ruled out.

If low-altitude contrails are unlikely, short sunlit sections of exhaust contrail due to aircraft at high altitude above and beyond the Control Zone could conceivably appear as bright "cigar shaped" objects, and these ice crystal contrails can persist for a considerable time. However this also seems most unlikely for several reasons.

We would first need to assume an angular elevation error on the part of the *Trislander* witnesses, so that their UAPs were not observed against the sea and islands at any time but remained just above the visual horizon. Then a LOS tangential to the horizon from an aircraft at 4000ft intersects an altitude of 25,000ft (the minimum realistic level for exhaust contrails) at a slant range of ~235nmi.[112]

At this range the LOS is running into an area of frontal cloud over the Bay of Biscay SW of Finisterre shown on the 1418 (overhead time) NOAA 18 satellite images (*Fig 18*), likely to lead to obscuration of the LOS by intervening cloud below the trail height, and/or to obscuration of the sun by thick cloud above the trail height. Visibility was estimated by Capt Bowyer at 100nmi above the haze. But even assuming brightly sunlit contrails to be visible at >235nmi in these conditions, we run into problems with the scale and rates of displacement.

The angular thickness of the UAPs was established to be in the range 0.05° - 0.1° (*Section 3*). UAP#1 with an angular thickness of 0.1° would be equivalent to a horizontal length of contrail almost ½ mile thick, in vertical depth, or much more than this in horizontal breadth if we consider the perspective projection of a thin layer, which is the normal form of wind-dispersed

[110] Moisture is still a factor in the optical thickness of such a haze even if RH is far below saturation. Hygroscopic salt particles in a salt sea haze only begin to swell at more than 70% RH, but dusts and biological aerosols such as pollen will react similarly to a lower RH.
[111] http://www.met.reading.ac.uk/~brugge/ukclimate.html#HChannel%20Islands
[112] The 1328 high-res MODIS image (*Fig.19*) shows a pair of high contrails lying just S of Guernsey and casting shadows on the cirrus tops. Similar nearby contrails would, if any were visible at 1406, be a number of degrees above the horizon.

contrails. These are improbable dimensions for even a very dissipated contrail, especially given the required extreme brilliance (implying high crystal density and little dispersal) and the fact that the LOS intercepts the *underside* of the high-altitude trail in this case, requiring light to be transmitted through the contrail rather than reflected off the directly sunlit top.

Some unusual coronal diffraction effect might be indicated. However, let us remember that there were two of these UAPs, and that both were observed to have a similarly-located dark band, a detail which was preserved during an overall westward azimuth rotation of the UAP#1 LOS by about 10° and a simultaneous superimposed eastward *counter*-rotation of the UAP#2 LOS by about 5° relative to LOS #1 (or in other words #2 rotates to the west at half the rate of #1). At the likely minimum slant range of an exhaust contrail #1 has probably moved westward by ~20nmi, corresponding to a real ground speed of ~100 knots. Winds were less than about 50 kts at all levels at all of the radiosonde stations examined, and upper winds, dominated by the approaching frontal system, were generally *from* the southwest/west, as indicated by noon radiosonde ascents and satellite photo sequences. Winds at ~25,000 ft recorded at Brest were SSW, less than 20 kts, falling lighter at higher altitudes. Even if the #1 LOS is assumed static, and the relative #2 rotation is then interpreted as a real 25°/min eastward drift, then the minimum real (easterly) speed exceeds twice that of the maximum (northeasterly) wind vector, and the implied ~50 knot wind velocity shear between the two trails is at odds with the persistence of their identical form and internal detail during some 12 minutes of binocular observation.

Finally of course there is the corroborating report of the Blue Islands *Jetstream* pilot. The description of a “yellow/beige” cigar might be less problematical in terms of reflectivity than the “brilliant sparkling yellow” of the *Trislander* report. But on this hypothesis there is no natural physical relation between the sightings. The coincidence of two geographically very remote sunlit contrails producing a similar visual effect at reciprocal azimuths at the same time is not very attractive.

In summary, aircraft contrails are a rather poor explanation

Plausibility (0-5): 1

f) ship tracks

Ship tracks (otherwise known as ship trails or ship plumes) are analogous to jet contrails, cloud trails that form at low level, usually a few hundred or a thousand metres altitude, in the wake of ships. They are caused by particulates from ship exhaust stacks rising into clean air which is nearly saturated (or even supersaturated) with water vapour. The particulates, such as sulphur dioxide, act as condensation nuclei and encourage the formation of droplets. The droplets so caused are smaller and more numerous than those condensing spontaneously in natural cloud, so the total droplet surface area per unit volume is higher than for natural cloud, meaning that the albedo is higher and the trails reflect sunlight more efficiently than natural cloud.

Ship tracks often occur embedded in a layer of natural altocumulus (see *Fig.32*) but sometimes occur in isolation in a relatively clear sky. They generally plume many tens of km downwind, spreading to between 0.5-5 km in breadth, and persist for days because the droplets are too small to rain out quickly, clearly visible at optical wavelengths as bright “contrails” on satellite photographs. (They are especially bright in infrared, but they are usually too deep in the atmosphere for effective detection by satellite IR.)

Some of the points raised in relation to aerodynamic fog contrails are also applicable to ship tracks. But ship tracks do not dissipate rapidly like fog contrails, and we do at least have radar and other evidence (*Section 4*) that at least two ships probably of moderate size, one a Channel ferry, were in the approximate area of the UAPs at the sighting time.

We can imagine that long ship tracks from two ships heading broadly N-S and S-N were oriented at an oblique angle to the LOS from both observer locations and thus foreshortened. Also a fortuitous cloud hole in dissolving altocumulus at 10-12,000ft (*Section 5*) could conceivably allow just portions of these side-by-side trails to be illuminated. Moreover it would not be impossible for (say) a single jet contrail or cloud streak at higher altitude, oriented E-W, to cast a shadow across both illuminated trails in a similar way, giving rise to two bright cigar-shaped UAPs each bisected by a dark band.

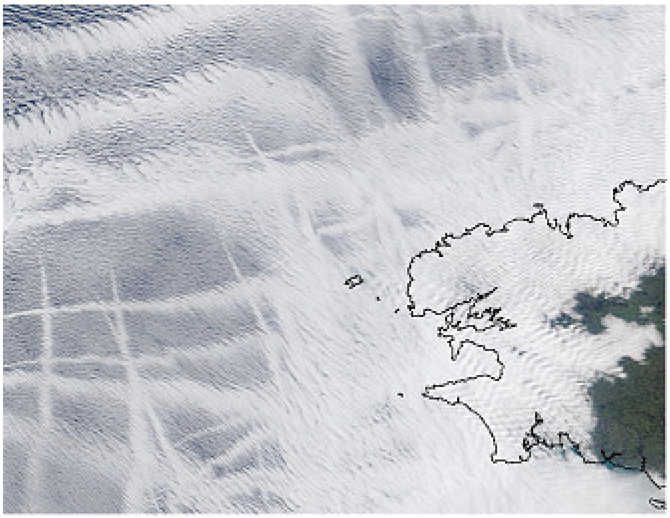

Fig.32 Ship tracks off Brittany, France. Photographed at 500m resolution, Jan 2003. (Aqua MODIS, NASA)

During the course of the sighting the trails could retain their relative positions and orientations under winds of only a few knots, spreading slightly and drifting slightly NNE towards the approaching *Trislander*. Thus the growth in apparent size and reduction of the subtended bearing angle would be a complicated function of these various movements plus the fact that the seeding-head of the nearer northbound trail would be shifting to the right whilst that of the farther southbound trail would be shifting to the left. The LOS from the *Jetstream* to the eastern trail at 1414 would be around 340° (nearer 7 o'clock than the reported 8, but not too far off) with the sun angle meaning that the *Jetstream* pilot did not have the benefit of forward scattered sunlight or possible transmissive effects that might have enhanced the brilliance for the *Trislander* witnesses in the N but instead saw a relatively dull reflection that was "yellow/beige".

The yellow and/or yellow/beige colouration mentioned by all observers (even "orange" in two instances) has no obvious interpretation. Ship trails would normally appear white under high angle sunlight (45° elevation rules out horizon reddening). Some reddening due to scattering extinction by the haze layer reported at ~2000ft is possible, and there is some witness evidence that the colouration deepened during the *Trislander's* descent towards the layer, which would be consistent with a longer optical path length through a scattering medium.

But there are several problems with this interesting theory.

The least serious is that there is no sign of ship trails miles long on satellite images (either in visual or IR). Granted the resolution is poor at 1415 but both suspect ships (among others) should already have been underway in the area during our high resolution MODIS look at 1328. Given that the trails are to be brilliantly illuminated by direct sunlight (*ex hypothesi*), and so should be at least partially unobstructed by higher cloud, some glimpse might have been hoped for.

The stability of the illusion over many minutes of binocular observation is also a difficulty, despite what was said above. And one wonders why such prominent and unusual trails were not visible from the ground and the air by observers not in a position to be deceived by the illusion. It was reported to us second-hand that an unidentified pilot said that the weather that day was "unusual" in some unspecified way, but if the pilot in question had seen monster ship trails we think that we might have heard about it. In any case this is mere hearsay, whereas we know from the ATC audio record that the BAe 146 asked to look down from a few thousand feet above the area reported nothing unusual that might account for the sightings.

A big problem with the radar-plotted positions of the suspected ships (*Section 4*) is that the initial LOS to the western ship not only makes a somewhat large angle with the LOS to the eastern ship (we could cope with a factor 1.5 visual error) but it is also well to the W of Casquets Lighthouse, by something like 5°, and *ex hypothesi* this south-moving ship is at the head of a trail cloud pluming ~N from this position (surface winds being roughly SSW) so any sunlit section of trail would lie somewhere still further to the W of this LOS. Yet Capt Bowyer stated that his LOSs to *both* objects lay to the left (E) of the Casquets Light which was visible at the time (*Section 3*). At no point on the *Trislander*'s track would the western ship position have been seen to the left of Casquets and any ship-trail cloud UAP would have to be significantly to the right of Casquets at all times. And especially telling is that these LOSs to the ship trails could not possibly have rotated (due to parallax) so as to *cross* one another, as the bearings to the UAPs explicitly did.

In addition to these objections, the *Jetstream* pilot would have to have flown right between or possibly over both of these hypothetical ship tracks *en route* past Guernsey and would potentially have had many minutes of good views at changing angles of sight and angles of illumination. It makes little sense that only a couple of minutes later he would look back at one of them and fail to recognise what he was seeing, given that the illumination conditions and visual appearance of the cloud (seeming unchanging during binocular observation at the time) should have remained rather constant. Moreover, it is hard to see how trail clouds associated with either ship could be the cause of an object which the *Jetstream* pilot located "NW of Alderney".

Finally, prominent ship track clouds at ~2000ft the Guernsey-Alderney area might be reported by observers at sea or on land. We made inquiries *via* the Guernsey Harbour Authority, who were aware of no reports of unusual weather phenomena on that day.[113] Such clouds would constitute striking low level altocumulus bands that might be recorded in routine local weather observations. Alderney and Guernsey airport half-hourly meteorological records (*Appendix C*) show no low-level cloud at all observed between 1150Z and 1550Z, with only remnants of dissipating 10-12,000ft altocumulus (1/8 cover or less) at the sighting time.

Plausibility (0-5): 1

g) lenticular clouds

Lenticular or lens-shaped clouds (*lenticularis*) are a type of lee wave cloud distinguished by an often striking symmetry and smoothness. These form due to standing gravity waves in the airflow when humid air is forced upward over an obstacle in conditions of static stability (i.e., minimal vertical circulation). The classic form is *altocumulus standing lenticularis*.

Well-developed lenticulars are generally seen when strong winds are deflected by high hills or mountain ranges (for which reason they are also known as *orographic*, or mountain-formed clouds), and the amplitude of the waves in these cases can reach tens of thousands of feet. The clouds form at altitude in the ascending moist air at the peaks of the waves, often above the freezing level so that they are sometimes composed at least in part of ice particles. These mountain clouds are typically large, often miles across. Given sufficient wave amplitude they can appear as approximate lens or almond shapes, or like stacks of elliptical plates with smooth surfaces and well-defined edges (*Fig. 33*).

A distinction is made between vertically trapped lee waves, and untrapped or vertically-propagating lee waves. Gravity waves can only exist in statically stable air. The trapping occurs where a stable layer at the barrier crest is sandwiched between unstable airmasses which are unable to support gravity waves. It is these trapped waves whose signature, when wave amplitude is high, is the lenticular cloud proper (see *Fig.33*). They are also characterised by a small vertical directional wind shear (i.e. little change in wind direction with height) and require an abrupt escarpment on the lee side of the barrier, the windward profile being relatively unimportant.[114] Untrapped waves, on the other hand, occur when the atmosphere is stable through a considerable depth and the waves are free to propagate upward. They generally occur in the presence of marked wind shear aloft and can be set off by broader mountain ridges. The signature cloud of these waves is usually a less compact higher-altitude cirrus form called *orographic cirrus*.

Strong winds approaching Beaufort force 7 (moderate gale) in the stable layer are usually considered the minimum necessary for mature trapped lee wave clouds to form. A figure of at least 20 knots is widely cited. A UK Met Office source gives 20 knots and 300m (1000ft) vertical barrier height as the minimum conditions for trapped waves.[115] A study in New Zealand

[113] Letter from AJB Pattimore, Deputy Harbourmaster, Guernsey Harbour Authority, to Paul Fuller, 14 Aug 2007.
[114] http://www.caem.wmo.int/_pdf/turbulence/OrographicTurbulence.pdf
[115] *ibid.* A striking satellite photograph in *ref.113* shows a stratus sheet rippled by orographic turbulence extending hundreds of km in the lee of all but one of the South Sandwich Islands, a chain of mountainous volcanic islands in the S Atlantic. The responsible mountain heights here are between 1800 and 3600 ft. No effect is detectable from the lower island of Leskov (625ft, 190m).

indicated that winds in excess of 20-25 knots were required blowing at <30deg to the line of the orographic barrier, and found wavelengths of 4 - 20km with an average of 15km.[116] Similar studies in the Sierra Nevada, California, have found wavelengths in the range 4 - 32km, with an average of 10-15km.[117] The American Meteorological Society glossary also gives 5 - 35km as the range of wavelengths for trapped lee waves in the lower troposphere (1-5km altitude).[118]

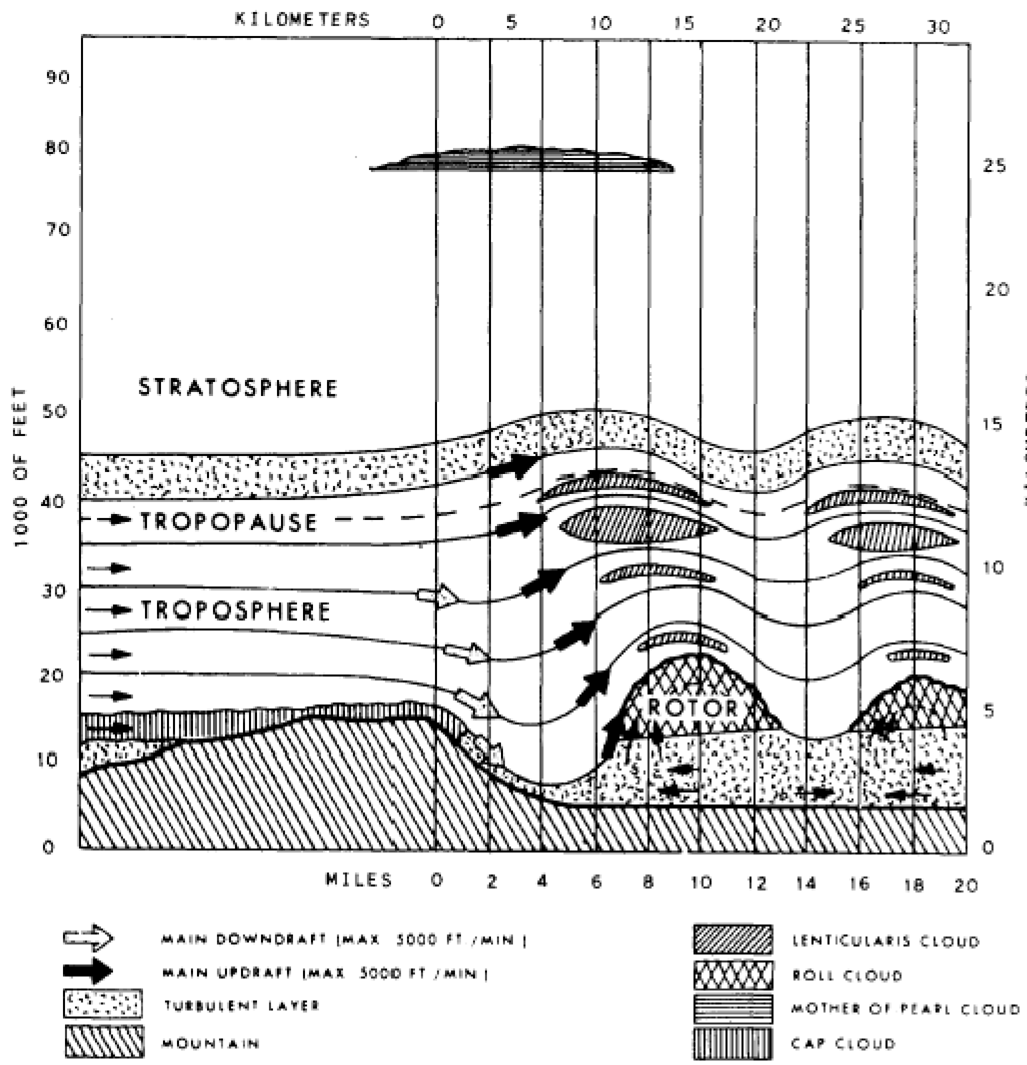

Fig.33. General structure of a trapped mountain lee wave and its signature clouds
(from http://windsaloft.tripod.com/info/rotor.htm)

[116] Alistair Reid, *Mountain Waves & Clouds: Investigating the occurrence of cloud-producing mountain waves.* www.physics.usyd.edu.au/pdfs/current/2002projects/Reid_MountainWavesClouds.ppt

[117] Vanda Grubisic and Brian J. Billings, *Climatology of the Sierra Nevada Mountain Wave Events,* Desert Research Institute, Reno, Nevada, Revised manuscript submitted to the Monthly Weather Review April 5, 2007 www.eol.ucar.edu/projects/trex/publications/papers/wave070405revised.pdf

[118] http://amsglossary.allenpress.com/glossary/search?

The Lifted Condensation level, H, is the height at which an air parcel of a given constant moisture and heat content will become saturated due to adiabatic expansion-cooling when mechanically lifted. The formula[119] is

$$\frac{0.83}{100\,m}\,°C = \frac{T - T_d}{H}$$

where T and T_d are respectively temperature and dewpoint. Or approximately

$$H(m) = 120(T - T_d)$$

which for Guernsey surface readings taken at 1350 and 1420Z (*Appendix C, Table 2*) gives H = 720m (~2400ft) and 960m (3150ft). Thus roughly speaking one would expect any orographic uplift cloud to condense at about 3000ft at the sighting time, about twice the altitude visually estimated independently by two pilots, but an order-of-magnitude match is probably good enough given that this is a rule of thumb and the true sea-level humidity is uncertain.

Unusual lenticularis was an early candidate for our UAPs. In the present case there is no high mountain barrier - barely even 1/3 of the minimum 300m cited - or strong wind. However the island of Guernsey does constitute a modest barrier (about 100m, 330ft at the highest southern point) to a SSW sea level breeze, and the triangulated UAP positions (see *Fig.7*) do fall in the lee of the island. Jersey meteorologist Frank LeBlancq pointed out[120] that the presence of a temperature inversion (see *Section 5*) indicates a layer of statically stable air - one known pre-condition - and speculated that lenticular cloud might form in stratocumulus even at low level. On the other hand we also sought the opinion of Robin Hogan, a cloud physicist at Reading University. Based on information supplied including the Brest balloon ascent readings (*Fig.34*), satellite images and local weather observations it was Dr Hogan's opinion that lenticular development was "very unlikely".[121]


Fig.34 Lenticularis in the lee of Ben Wyvis, Scottish Highlands, December 2007 (M. Shough)

[119] Petterssen, S., *Introduction to Meteorology,* McGraw-Hill, 1958 p.83.
[120] Email to Tim Lillington and Martin Shough from Frank LeBlancq 27.07.2007
[121] Emails to Martin Shough from Robin Hogan, 28.08.07

The surface breeze measured on Guernsey from 1350-1420 was only 6-7 knots, or about ¼ of the typical minima measured in mountain wave studies. The barrier height is not great, and the barrier profile - an abrupt windward side sloping very gradually to sea level on the leeward side - is the exact opposite of the optimum shape. There is reasonable doubt that a wave having an amplitude in the order of 10 times the barrier height (to reach the condensation level) could be kicked off in these conditions.

But it seemed somewhat plausible to us that the distributions of the causal variables must have a tail end, and that in the right conditions of atmospheric stability and humidity even a modest cliff and a slight breeze might sometimes generate a short-duration, possibly poorly-developed fragment of lenticularis. After all, might this not explain why the clouds were so small (angular size >1deg at 12nmi, or 22km, indicating diameter in the region of ~400m) compared with the diameters of typical lenticularis, and with the bulk of the parcel of air potentially lifted by a generally flattish island the size of Guernsey (63 km^2, 24.3mi^2)? Unfortunately the theory falls foul of problems with wavelength, amplitude and lenticular definition.

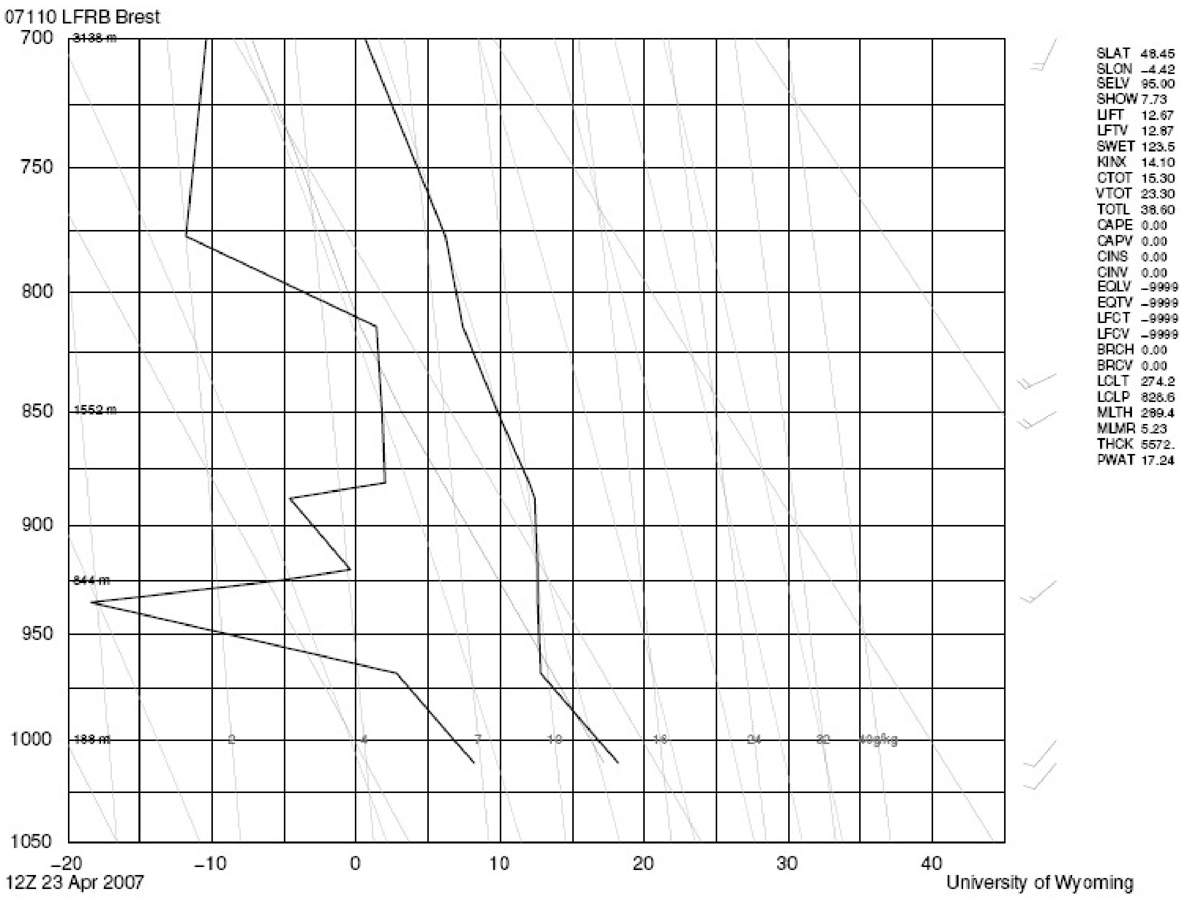

Fig.35. Brest radiosonde ascent profile to 700mbar, noon, April 23 2007.
See Note 120 & Appendix C
(courtesy Dept Atmospheric Science, University of Wyoming College of Engineering)

Firstly we found that the particular importance of wind speed is as the main factor in determining the *wavelength* of the orographic wave. The values are directly proportional.[122] For a given atmospheric stability, the higher the wind speed the longer the wavelength. It is the wave *amplitude* that is governed principally by the topography. The triangulated UAP positions in *Fig.7* are approximately 18 and 36km from the south coast of Guernsey. It is striking that these distances could be consistent with lenticularis in the first two peaks of a mountain wave having a wavelength of approximately 18 km. But satellite measurements have shown that a 15km wavelength equates to a 30m/sec wind,[123] or approximately 60 knots, which is violent storm force (Beaufort #11). One would reasonably expect that light winds, and a low orographic barrier of only a few hundred feet, would produce not only small amplitude waves but, in particular, wavelengths at the low end of the ranges recorded, i.e., perhaps a few kilometres. The wind speed measured by an anemometer at the hypothetical uplift location (Guernsey Airport, not far from the cliffs at the south of the island) was a slight breeze (Beaufort #2), only about 1/10 of the speed that typically produces 15km wavelengths in the cited studies. Therefore an 18km wavelength in this case seems implausible.

Secondly, the very compact shape and "sharply defined edge" of the UAPs is a problem. The lenticular definition, we learned, is proportional to the wave amplitude. Generally, for a given wind speed, the wave amplitude is proportional to the size of the barrier, so at first sight it seems that in this case, with a very modest barrier, a large amplitude and well-defined lens clouds would not be expected.

A possible escape from this conclusion offers itself when we find that the degree of stability of the air layer is also a factor: A shallow layer of exceptional stability can produce higher amplitude waves than can a deep layer of only moderate stability. (This, in general, is why trapped lee waves produce well-defined lenticularis and untrapped lee waves do not.) So can we posit an extremely stable trapped layer?

Direct meteorological evidence is inconclusive.[124] However it happens that the stability of the wave layer is in turn inversely proportional to the wavelength,[125] so exceptional stability would dictate short wavelength, and this is in tension with evidence for what appears to be a problematically long wavelength. The wave cloud theory therefore appears not to be internally consistent.

Another factor is that orographic waves can propagate many tens of kilometres and are in general

[122] http://www.caem.wmo.int/_pdf/turbulence/OrographicTurbulence.pdf

[123] Reid, Alistair, *op. cit.*

[124] The noon radiosonde ascent at Brest on the SW of Brittany (*Fig.35* and *Appendix C*) shows an unstable layer below about 500m indicated by a decreasing Theta (potential temperature). Here, the atmosphere could not support gravity waves below about 500m, and it was far too dry for cloud condensation below about 1500m (email to Martin Shough from Dr. Robin Hogan, 28.08.07). No capping inversion is indicated, although there is a near-isothermal layer from ~500-1200m. But the profile is stable everywhere above 500m (indicated by a high positive Lifted Index of 12.67), suggesting that lee waves at the top of the unstable layer would not be vertically trapped and signature lenticularis would be unlikely. The meteorological model in *Section 5* shows a strong inversion near the N Breton coast, with these highly stable conditions probably decaying over the sea south of the Channel Islands with a much weaker inversion here indicating decreasing stability. To the north, the noon ascents at both Camborne and Herstmonceux showed an unstable surface layer only about 200m deep, but a lower positive Lifted Index indicating overlying air still on the stable side although somewhat less stable than at Brest.

[125] http://www.caem.wmo.int/_pdf/turbulence/OrographicTurbulence.pdf

associated with downstream turbulence and pressure fluctuations of concern to pilots. Up- and down-draft rates of hundreds of feet per minute occur in well-developed mountain waves, and rotor or roll clouds[126] in the vicinity of lenticularis are associated with especially dangerous turbulence with up to ten times these rates. In our earliest interview we asked Capt Bowyer to describe the conditions of the flight, which brought the *Trislander* in downwind of Guernsey in a near-direct line with the hypothetical direction of orographic wave propagation. In fact it happens that when passing through the apparent ~2000ft altitude of the UAPs the aircraft was (hypothetically) itself almost exactly one 18km wavelength downwind from the triangulated position of UAP#1. But flying conditions were "standard", Capt Bowyer reported; it was a "normal day". Did he experience any turbulence during the approach, or in the descent to Alderney? "None at all." (See *Appendix B*)

The only instrument evidence we could find relating to local pressure variations was the regular surface observations made by Guernsey and Alderney Airport Met Offices. Guernsey's high ground is at the S end of the island, and it is here that SSW winds generating wave clouds would be obstructed by coastal cliffs. The expected result would be to build high pressure at the southern edge of the island where Guernsey Airport is located. The orographic wave would then induce alternating high and low pressure in the lee of the island, extending towards Alderney. Raised pressure would tend to accompany adiabatic compression in the troughs, and lowered pressure might be found below the peaks owing to adiabatic expansion-lifting of the overlying air. The 18km wavelength indicated by the triangulated UAP locations would lead to a wave peak close to the range of Alderney, where a low pressure reading might be expected.

The pressure figures read at Guernsey at 1350Z, 23 April 2007, were obtained thanks to the airport Senior Meteorological Officer, Tim Lillington.[127] At the altitude of the airport (336ft MSL) the reading was 1009.1 mbar. Sea level adjusted (QFF) pressure was 1021.4mbs. With appropriate adjustment this could be compared with the 1350Z Alderney QNH surface pressure reading recorded in the CAA report (*Appendix* A).

Sea level pressure QFF at Guernsey, 1021.4 mbar, is a shade higher (+0.4 mbar) than the QNH sea level pressure at Alderney. QNH pressure at Alderney was 1021 mbar, which is adjusted from the ground level reading by assuming the International Standard Atmosphere (ISA) pressure lapse rate of 27 ft/mbar, whereas QFF pressure at Guernsey (1021.4) is adjusted by using measured temperature. So if the actual pressure lapse rate exceeds ISA then QNH will underestimate sea level pressure relative to QFF; conversely, if the lapse rate is less than ISA it will overestimate it. In this case 336/(1021.4 - 1009.1 mbar) = 27.3 ft/mbar. So the true lapse rate here is very slightly greater than ISA and QNH will very slightly underestimate the pressure, probably accounting for the very small 0.4 mbar differential between QNH and QFF in a flat pressure field containing Guernsey and Alderney. We can interpret this to mean that there is no evidence of the pressure gradient between high pressure at the S end of Guernsey and low pressure at Alderney that would be expected to be associated with an orographic wave of the wavelength indicated.

Capt Bowyer remarked to us that he has seen lenticularis many times when flying many routes

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[126] Rotors are vortex clouds that generally form nearer the ground underneath the lenticular clouds, often at the base of a stack (see *Fig.31* and below).

[127] Email to Martin Shough from Tim Lillington, 07.08.07

and insists that he would not have been deceived by a lenticular cloud. With the benefit of 12 minutes observation both with naked eye and 10x binoculars he described both objects as appearing to be "very sharply defined", and so bright as to appear self-luminous. A second witness described “very bright” white-yellow light as bright as a specular reflection of sunlight - “like the sun reflecting off glass”. Another witness judged that the light was “brilliant . . . A lot brighter than a reflection of the sun would create.” These estimates of brightness are not at all suggestive of daylight scattered by any ordinary cloud.

We might be able to rescue the theory by assuming some unusual coronal effect. Coronas and iridescence have been seen in mountain clouds, an effect (sometimes called *irisation*) which could be relevant to perceived colour and brightness. Such coronas are explained as diffraction by water droplets (or small ice particles, but not in this instance) and so imply illumination from behind the cloud at a small angle to the line of sight.

A bright corona would need illumination approaching zero degrees. In the present case a cloud would be directly illuminated at 45° to the line of sight. True, the limiting angle of diffraction is inversely proportional to droplet size, so a fine mist can diffract incident light through a larger angle than can large droplets; but unfortunately the brightness efficiency has an exactly opposite dependency, i.e., the intensity of the diffracted light is proportionately weaker, and the forward scattered intensity at such a large angle would be negligible. Coronal diffraction in cloud is normally only seen at all at scattering angles <40° And it does not seem that this could explain the reported yellow colouration anyway, since the dominant colours of wave cloud coronae are red and blue. Some observers have reported red and green, but not yellow.[128]

Generally the iridescence seen in these coronae occurs in the region of low droplet density at the cloud edge rather than across the denser opaque body of the cloud. Our UAPs appeared uniformly bright (apart from the vertical “graphite grey” bands on each). One could try to speculate that in the present case a less well-developed lenticular cloud has a lower density overall, and is more like a translucent mist. But this seems in tension with the excellent lenticular definition required to explain the observed “sharply defined” edges.[129]

With regard to shape and definition we should note that rotor or roll clouds are, as mentioned, turbulent vortex clouds occurring in parts of the mountain wave below the level of lenticular clouds. They are sometimes described as columnar “cumulus bar” clouds (or in higher/colder conditions than obtain in the present case they may occur as semi-transparent cylinders of thin cirrus sheets). They can have fairly well-defined edges, like their lenticularis cousins, and form with the horizontal roll axis lying perpendicular to the airflow.[130] Some similarity can be argued between the typically cylindrical form of roll clouds and the UAPs in this case. But similar problems arise.

[128] J. A. Shaw and P. J. Neiman, Coronas and iridescence in mountain wave clouds," Appl. Opt. 42, 476-485 (2003) http://www.opticsinfobase.org/abstract.cfm?URI=ao-42-3-476

[129] Given such a mist it is conceivable that a specular glint reflection from a distant sun-glitter pattern on the sea (for example) might work as a secondary source of diffraction close to the line of sight. Such a scenario is discussed in *Section 6d*.

[130] Ozawa, H., K. Goto-Azuma, K. Iwanami, and R.M. Koerner, 1998: Cirriform Rotor Cloud Observed on a Canadian Arctic Ice Cap. *Mon. Wea. Rev.*, 126, 1741–1745. http://ams.allenpress.com/perlserv/?request=get-document&issn=1520-0493&volume=126&issue=06&page=1741#i1520-0493-126-6-1741-corby1

Would a series of unusually well-developed ("sharply defined") rotor clouds occur in isolation from their usual lenticular partners? These are the most energetic of mountain wave features, and seem rather *less* likely to occur given light winds and a very modest orographic barrier. Moreover the same red-blue-green coloration is likely to be observed in rotor cloud coronae,[131] although it is true that because they are usually associated with a turbulent layer extending to the ground in the lee of the barrier, they can often pick up dust particles and other debris, which might affect the diffraction properties of the cloud edges (but would tend to increase the optical thickness, further reducing any translucency in the body of the cloud).

Howsoever no turbulent, low-level winds were recorded by met observers on Guernsey, or on Alderney although the latter lies close to where turbulence (or even a reversed surface wind direction) might indicate the rotor circulation under the second lee-wave peak (UAP#1). Neither were rotor clouds (or indeed any low clouds at all) recorded at either station. Guernsey's Senior Meteorological Officer Tim Lillington confirmed to us that only "normal" altocumulus at 12,000ft was being observed.[132] And of course the 18km wavelength consistent with the triangulated UAP positions remains anomalous in terms of the wind speed.

We have searched satellite images in the visible and IR without seeing any persistent large phenomena in the area indicated. Although the best resolution (250m) is not available nearer than about 40 minutes before the start of the sighting, and there is then a broken veil of intervening high cirrus, no prominent compact clouds are discernable in the area. We found a rather bright cloud spot a few miles east of Guernsey on a Meteosat 8 visible light image timed at 1415Z and took note of an opinion given to us by Meteo-France (Centre de Météorologie Spatiale) that this could be "an orographic cloud development".[133] However we were able to discount this possibility.

Viewing successive images in a slideshow discloses that the cloud feature is actually developing before it reaches Guernsey (*see Fig. 36*), and moreover infra red cloud top data indicate that this is at about 15,000 ft, which appears to be confirmed by the fact that instead of following low level winds of a few knots it is moving rapidly from W to the E of Guernsey at about 35 knots (consistent with the UK Met Office *Form 214* upper air forecast for 50°N 02°30'W, and the Jersey Airport local area aviation forecast, both of which show winds swinging 230-260° through this altitude).

Whatever its origin this cloud was also far too high above the observers' near-horizontal or even depressed lines of sight to the UAPs. It was also moving in the wrong direction (W to E at ~0.75°/min) across the line of sight from the Trislander, which LOS rotates in the opposite sense (E to W) at about the same rate during the observation.

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131 *Ibid.*

132 "Alderney airport observers would not have made the distinction [between standard and lenticular altocumulus] as they are not obliged to be that specific." (Email to Martin Shough from Tim Lillington) Nevertheless they, like Guernsey, reported no low level cloud at all.

133 Email from Pierre Blouch, Meteo-France, Brest, to Jean-Francois Baure, 12.07.2007

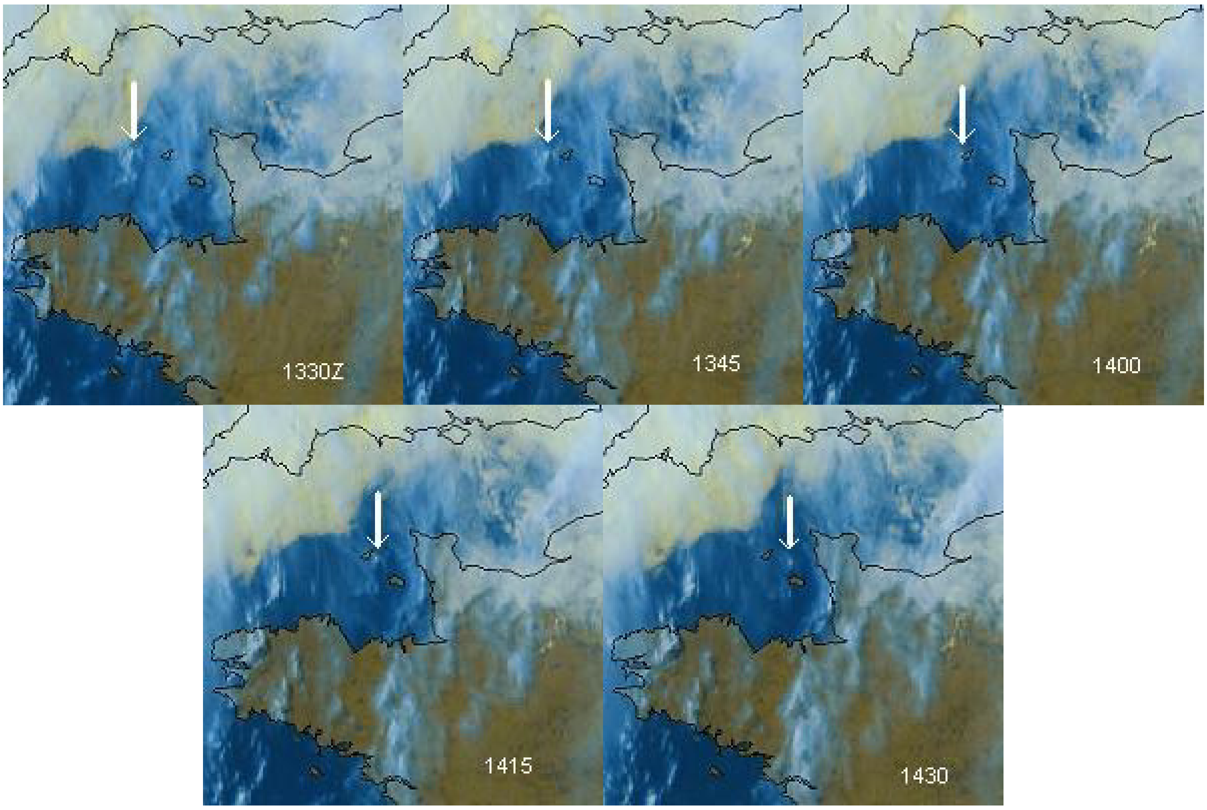

Fig.36. METOSAT 8 images timed 1330 - 1430Z, 23 April 2007. 4km resolution. Courtesy Loic Harang, Meteo-France, Centre de Météorologie Spatiale,

In conclusion, the lenticular cloud theory seemed initially promising, but we are disappointed by it. It is true that certain factors would be easier to explain if we could place some such phenomenon at the location. For example, colouration, absolute brightness, and other factors aside, the *relative* brightnesses of the of objects as seen looking towards the sun from the NNE and away from the sun from the south ("brilliant yellow" and merely "yellow/beige" respectively) might be qualitatively consistent with the forward-scattering and back-scattering respectively off the top of a sunlit surface like a bright cloud. But there are a number of meteorological and other problems. Also let's recall that there were two of these "clouds" each with identical dark stripes 2/3 of the way along their length. We have considered the possibility of jet contrail or cloud shadow(s) lying across them. But it would be asking a great deal for the same contrail shadow to do the same trick on two small clouds 18 km (about 10nmi) apart.

Plausibility: (0-5) 2

h) Military exercises etc

The UK Ministry of Defence's response to the information supplied to it by CAA indicated that MoD was aware of no UK activity that could be relevant. An inquiry was made to the UK MoD in respect of any military exercises or experiments carried out in the Channel area on 23 April. The MoD responded explicitly as follows:

> The MoD did not conduct any military exercises (naval, RAF or army) in the English Channel, nor is it aware of any known military activity involving other nations (e.g. France) on or about Monday 23 April 2007.

Channel Islands Air Traffic Control Zone were aware of no activity of any kind. The CAA Manual of Air Traffic Services describes the detailed regulations for the issuing of Notices to Airmen (NOTAMs) and Airspace Co-ordination Notices etc. connected with "Unusual Aerial Activity" such as unusual aircraft concentrations, air displays, races, competitions, scientific experiments, special Permissions and Exemptions, and special Flight Priorities of all kinds including Calibration Flights, Air-to-Air Refuelling, military deployments and exercises.[134] No individual or organisation to whom we have spoken having any connection to air activities in the area was aware of any such notifications, neither are we aware of any possible type of conventional air activity that would tend to fit the observations.

Of course it is true that we would not necessarily be made aware of highly classified activities; nevertheless the location would seem a poor choice for such activities on several grounds. Capt Patterson, pilot of the Blue Islands Jetstream, suggested (*Appendix B*) the possibility of some secret military technology deliberately deployed in public as a test of stealthiness, or similar. We are unable to rule this out, but we find it implausible.

Plausibility: (0-5) 1

i) Lighter-than-air (LTA) vehicles

Capt Patterson also speculated (*Appendix B*) that the yellow object he saw might conceivably have been a large balloon or similar.

Many types of balloons, dirigibles and aerostats, piloted, remote operated, tethered or free-floating, ranging from a couple of feet to hundreds of feet in size, continue to be developed and flown by companies and organisations worldwide for many uses including military surveillance, weather recording, scientific research, advertising, sightseeing and cargo lifting.[135] They are used in all parts of the atmosphere from near the ground to the stratosphere.

Meteorological balloons or other scientific research balloons released or tethered in the area would be subject to NOTAMs and other arrangements as indicated in *Section 6h*. The CAA Manual of Air Traffic Services[136] states that military operations or private piloted flights by balloons or dirigibles are subject to the usual clearances and Coordination Notices applying to any flights. We have found no evidence of any such activities. There is at present no clear radar evidence indicating the presence of unusual air vehicles of any kind.[137]
It's always possible that balloons or other types of LTA construction released at distant sites

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[134] Manual of Air Traffic Services, Sect 1., Ch.4, p.11, CAA July 2007
[135] http://aiaa.org/pdf/inside/05_TC_Highlights/aiaa-lta.pdf; http://www.centennialofflight.gov/essay/Lighter_than_air/LTA-OV.htm
[136] *Ibid.*
[137] LTA gas envelope fabrics are not as a rule conductive and therefore are not radar reflectors (although some small instrument calibration balloons are metal-coated for this purpose). But other parts of the bracing structure or payload of a large LTAV may well be.

could become lost, develop leaks and drift into an Air Traffic Control Zone, but this seems a most unlikely theory on various grounds. The low-level winds suggest that balloons or stray aerostats/dirigibles arriving in the sighting location (*ex hypothesi*, having attained approximate neutral buoyancy at about 2000ft altitude) would have drifted directly over or at least very close to Guernsey with potential visibility from the ground by meteorological and other observers for a total period of perhaps several hours. It seems highly unlikely that such an event would have gone completely undetected. This is especially the case given the extremely large sizes implied in this case (several hundred metres) and the brilliant colouration reported especially by observers located to the north. It also seems extremely unlikely that such spectacular vehicles, having come nearly to rest at low altitude in the Channel Islands area, would then be able to depart the area at wind speed unobserved whilst Air Traffic Control is actively alerting air traffic to be on the look out. Or if they came down in the sea or on land it's hard to imagine them escaping discovery. And in either case it's scarcely plausible that stray equipment of this scale and novelty would have gone unclaimed by the operators who would no doubt have been searching for it.

A number of other objections could be raised but the above seem sufficient.

Plausibility: (0-5) 1

j) Windscreen reflections

This is a theory which, although it may seem outlandish to the reader, has been seriously suggested to us and therefore requires to be seriously considered. It appears to be true that experienced observers have been deceived by windscreen reflections in the past. The independent sighting report from the distant *Jetstream* remains lacking in detail and the principle evidence comes from the visual observers in the *Trislander*. Is it possible that they could have been deceived by an internal windscreen reflection?

All three interviewed *Trislander* witnesses used descriptors such as "brilliant", "very bright", "sparkling" etc., and in one case "brighter than a reflection of the sun could have been"; and two used terms such as "sunshine yellow" or "sunlight coloured". All this terms suggest bright specular reflection of direct sunlight from a shiny surface. However the objects were observed whilst the aircraft was reportedly not in direct sunlight. According to Capt Bowyer the sun was masked by intervening high cloud. Nevertheless, let us suppose that the cockpit was directly illuminated by bright sunlight.

Any bright source of reflection that was imaged in the windscreen only a few degrees away from 12 o'clock and near the horizon level could not be far from the line of sight. In fact it is easy to see that it could only realistically be a reflector situated on top of the instrument panel a few inches from the glass (see *Fig 36*). One would imagine that such a source would be obvious in plain view and presumably a familiar feature of the cockpit. Capt. Bowyer had flown this route hundreds of times in the same Trislander (G-XTOR) over the course of 8½ years - no doubt often with a sunlit cockpit. Would he never before have noticed an internal sun reflection so extraordinary that he now watched it with and without binoculars for many minutes, talked to passengers about it and made repeated requests to ATC for radar assistance?

With the source of the reflection little more than arm's length away from the eye, motion relative to background features would be revealed by quite small head and body movements. How likely is it that a windscreen reflection (even one, never mind two) would contrive to remain aligned so nicely with the horizon elevation? This is implausible when the aircraft is flying straight and level, and becomes insupportable from the moment the aircraft begins descent, when the pitch of the fuselage varies by as much as 20°.

The reflection geometries for a person in the left hand cockpit seat and a person several rows back in the passenger seats will be different. Kate Russell's two sightings occurred each time the nose dropped during the descent, and she lost sight of them again when the nose was raised by only a few degrees. This makes sense in terms of external objects near the horizon elevation (*Section 3*) but is only possible to interpret in terms of an internal windscreen reflection if the reflection geometry was quite sensitive to the changing vertical angle of illumination. In this case it seems likely that when the changing geometry intermittently favoured Kate Russell's eye position it would have simultaneously *dis*favoured Capt Bowyer's. But there was no change at all in the appearance or brightness of the objects as seen from the cockpit.

There was a progressive change in the angular size of the objects, a factor-3 increase in apparent width during the course of the sighting. This is extremely difficult to understand in terms of a fixed reflector inside the aircraft.

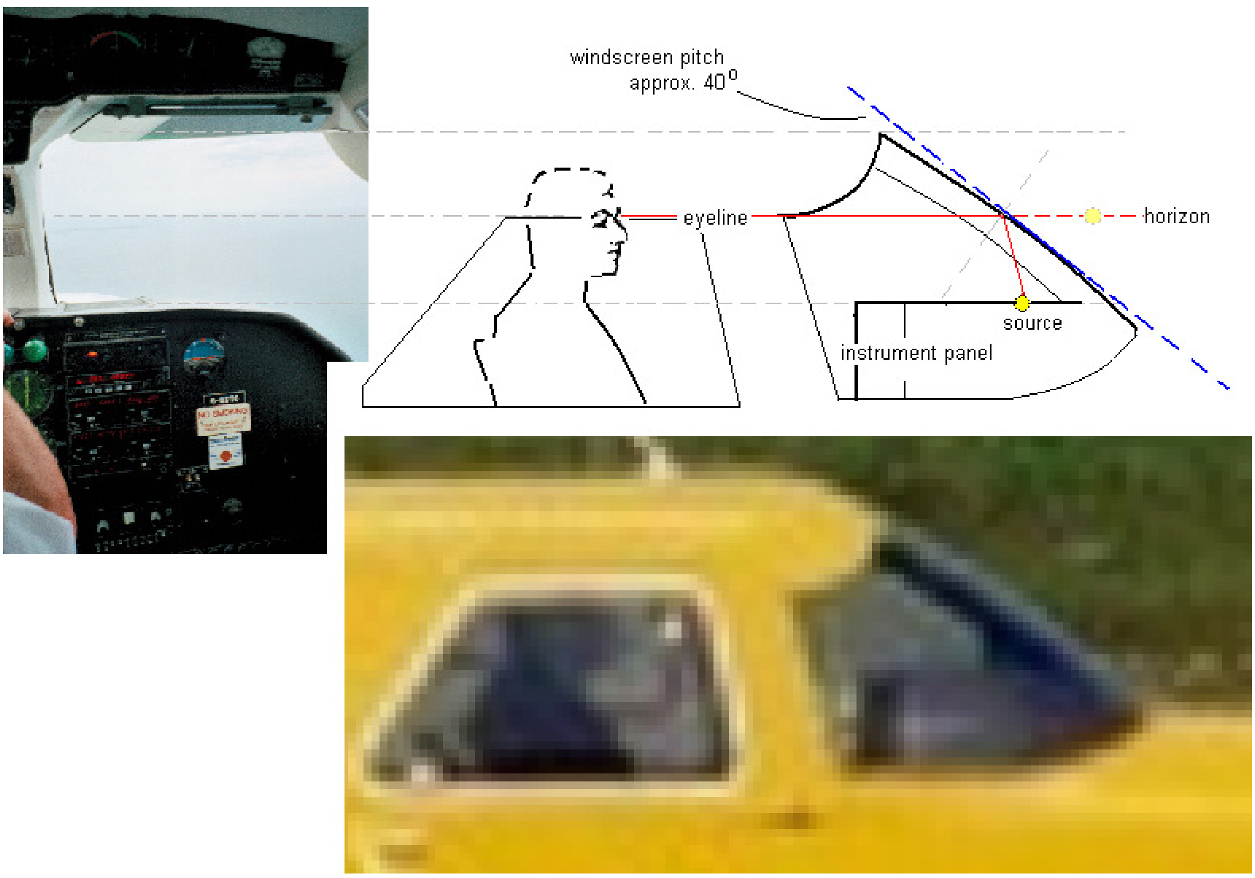

Fig.37. Geometry of an internal windscreen reflection

The spontaneous appearance after several minutes of a second reflection, identical but smaller, displaced from the first and moving in relation to it, again progressively, by several degrees, is impossible to understand.

The UAPs were watched with naked eye and 10x binoculars, presenting a "sharply defined" outline. A sharply focused image of a cockpit reflection would probably require active refocusing of the binocular eyepieces from a default setting (probably this would be a focus setting for distant aircraft and other objects at effective infinity) to a minimum distance of a few feet, and even if this were optically possible it would be a notable activity. It is very hard to imagine an experienced airborne observer like Capt Bowyer defocusing the horizon and distant islands in order to bring the UAPs into focus along with the windscreen frame and nose of the aircraft without realising that he was looking at an internal reflection.

And can we seriously suggest that Capt Bowyer would have altered the heading of the plane to improve his view of an internal reflection because the windscreen divider was in the way? Can we really believe that the passenger in the seat behind Ray borrowed his binoculars and viewed this same reflection for perhaps minutes from a different angle? This process no doubt involved some peering around the windscreen divider and over shoulders, and turning of heads, which would necessitate eye motions of an amplitude quite significant in relation to the length of the reflection raypath inside the cockpit. One would expect that erratic and gross parallax changes would quickly betray the presence of a windscreen reflection.

Finally, this theory is impotent to explain the simultaneous Jetstream observation.

Plausibility (0-5): 0

k) earthquake lights (EQL)

Earthquake lights fall into the general category of "earthquake precursors", phenomena believed by geophysicists to be symptomatic of the building and discharging stresses that sometimes lead to earthquakes. These phenomena include electrical, visual, infrared and other possible signals, but the field is in general poorly understood and certain reported phenomena are controversial. Reports of unidentified lights have been associated anecdotally with earthquakes for centuries and today many geophysicists (although not all) accept that the association is real. But even now the exact causes and mechanisms remain obscure.

Most observations of EQL are "white to bluish flashes or glows lasting several seconds associated with moderate to large earthquakes".[138] The largest study of modern EQL sightings dealt with more than 40 reported examples during the 1988-89 quakes in Saguenay, Quebec.[139] According to Derr they fell into 6 types of luminous phenomenon: "(1) seismic lightning, (2) atmospheric luminous bands, (3) globular incandescent masses, (4) fire tongues, (5) seismic flames, and a newly-recognized category, (6) coronal or point discharges." The 1995 Kobe, Japan

[138] Derr, J., 'What are Earthquake Lights? Are they real?', US Geological Survey FAQ. http://earthquake.usgs.gov/learning/faq.php?categoryID=8&faqID=103

[139] St-Laurent, France, 'The Saguenay, Quebec, Earthquake Lights of November 1988 - January 1989.' *Seismological Research Letters,* 71, no. 2, p. 160-174, 2000

earthquake (Mag 6.9) produced 23 sightings within 50km of the epicenter.[140] They were "a white, blue, or orange light all with an upper height of 200 meters and a linear dimension of 1 to 8 km. The types of phosphorescent phenomena were classified as: lightning with zig-zag lines, swelling shield-shaped sources, upward-extending fan-shaped sources, or a belt of lights (including arc-shaped sources)."[141]

On the night of July 27-28, 1976, many people in the area of Tangshan, northeast China, reported strange multicoloured lights and loud sounds. Some people reported flashes of light, others saw fireballs flying across the sky. These were followed by loud roaring sounds. Workers at Tangshan airport said the noises were louder than aircraft engines. Pets and farm animals were behaving very abnormally. At 3:42 am on the morning of Jul 28, a magnitude 7.8 quake struck Tangshan and devastated the city, killing over 240,000 people. It was the deadliest earthquake of the century.[142]

Mechanisms proposed for EQL include piezoelectricity, heat of friction, sonoluminescence, phosphine gas emissions and more. Problems with the favoured electrical charge migration theories (such as the piezoelectric theory) have centred around getting a sufficient negative electron density to the surface through the rocks. A recent promising theory developed by Friedemann Freund of NASA suggests that EQLs are instead caused by positive hole charge carriers that turn rocks momentarily into p-type semiconductors.[143, 144] Coronal or point discharges, such as were observed at Saguenay, are believed to be strong support for this positive hole theory. We consulted Prof. Freund during our investigation of the Channel Islands phenomena.

The Channel area is not especially geologically active. After a notable quake below the Kent coast in 2007 (the strongest in the northeast Channel area since 1950 and the strongest inside the UK for 100 years) the British Geological Survey[145] listed only a dozen quakes (of all magnitudes) within 50km of the new epicentre since 1328AD. It is therefore the more interesting that this 2007 earthquake occurred on April 27, only four days after the UAP sighting over the Channel Islands.

Bearing in mind that the processes that eventuate in earthquakes develop with lead times of perhaps weeks or months, and that the deep geology of the English Channel might connect Alderney and the Kent coast, we considered that a related EQL four days earlier might be possible. With this in mind we looked at the geology and seismicity of the Channel Islands area.

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[140] Tsukuda, Tameshinge, 'Sizes and some features of luminous sources associated with the 1995 Hyogo-ken Nanbu earthquake', *Journal of Physics of the Earth*, 45, no.2, p. 73-82, 1997.
[141] Derr, J., op.cit.
[142] Chen Yong, et al., *The Great Tangshan Earthquake of 1976: An Anatomy of Disaster* (New York: Pergamon Press, 1988) 53.
[143] Freund, Friedemann T., 'Rocks that Crackle and Sparkle and Glow: Strange Pre-Earthquake Phenomena' *Journal of Scientific Exploration*, 17, no. 1, p. 37-71,2003.
http://www.scientificexploration.org/jse/articles/pdf/17.1_freund.pdf
[144] St-Laurent, France, and Freund, Friedemann T, 'Earthquake Lights and the Stress Activation of Positive Hole Charge Carriers in Rocks'. *International Workshop on Seismo Electromagnetics* (IWSE), 2005.
http://elfrad.com/FranceStLaurent_IWSE_2005.pdf
[145] http://www.earthquakes.bgs.ac.uk/earthquakes/reports/folkestone/folkestone_28_april_2007.htm

We found from Jersey Meteorological Dept/BGS records for the years 1996-2006[146] that the area is subject to a few earthquakes every year, mostly minor tremors of around Mag 1.0 or less, and mostly with epicentres near Jersey. The geological feature of most interest, however, was a fault or complex of faults known as the Alderney-Ushant fault system, passing down the Channel a few miles N of Alderney and extending in a NE-SW direction to the island of Ushant. And inside the boundaries of Alderney-Ushant system just NW of Alderney lies the deepest seafloor structure in the Channel, the Hurd Deep (*Fig.38*).

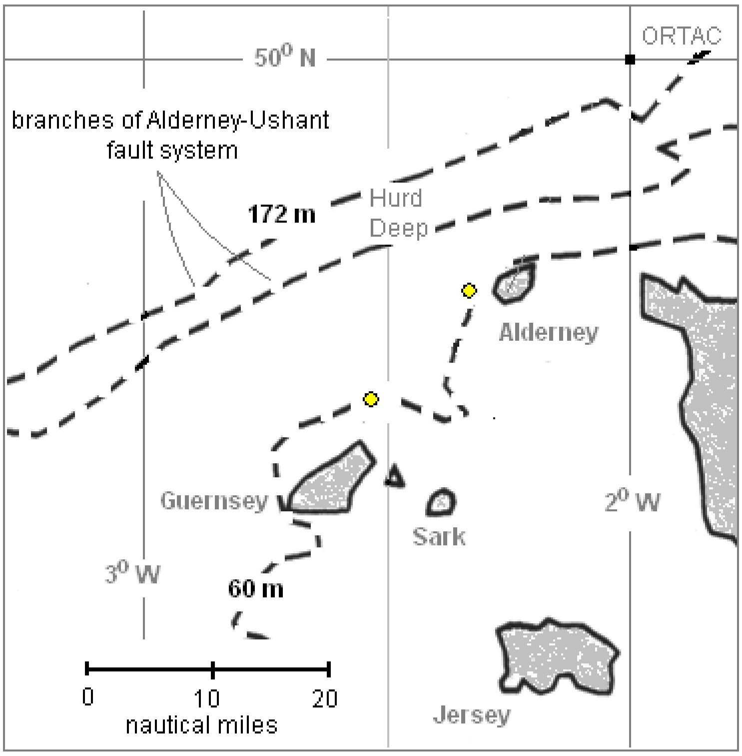

Fig.38. Approximate triangulated locations of UAPs (yellow circles) in relation to the Alderney-Ushant fault system.

We found ambiguous views about the geological origin of the Deep, recent opinion[147] seeming to favour a tectonic origin (i.e., a faulting origin) over earlier theories involving ancient tidal scouring. But a 1985 theory by Smith[148] proposing a catastrophic origin in a massive North Sea breakthrough event that created the Channel by flood scouring seems newly relevant in the light of recent sonar studies that have identified characteristic scars of a "megaflood" on the sea floor.[149]

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[146] http://www.jerseymet.gov.je/earthquake/earthquake_index.html

[147] G. Lericolais, P. Guennoc, J.-P. Auffret, J.-F. Bourillet and S. Berne, 'Detailed survey of the western end of the Hurd Deep (English Channel): new facts for a tectonic origin', *Geological Society, London, Special Publications 1996; v. 117; p. 203-215*

[148] Smith, A. J. 1985. 'A catastrophic origin for the paleovalley system of the eastern English Channel', *Marine Geology,* 64, 65-75.

[149] S. Gupta et al., *Nature* 448 (2007), pp 342-345

The geology of the underlying faulted Channel bedrock is that of an ancient rift valley whose contours it appears determined the profile of the overlying chalk landbridge. Consequently there was relatively low ground here, and when the Rhine outflow caused the level of the ice-choked North Sea to rise a river system probably developed through the lower-lying parts of the chalk, beginning an erosion which accelerated until eventually (perhaps aided by an earthquake trigger) the sea broke catastrophically through the land bridge to scour the Channel. It appears that the Hurd Deep is also a pre-existing fault trough that may have been deepened by scouring and then choked by up to 140m of sedimentary infill to its present depth of 75m.

The Kent quake at 0718Z, April 28, 2007, registered Richter Magnitude 4.2, and had an epicentre near Folkestone. It was followed by a series of nine Mag ~1.0 aftershocks until June 5. It occurred at a shallow depth (<5km) below the coast. The BGS moment tensor solution indicated nodal planes of the fault movement oriented either SSW-NNE or SE-NW. No tremors appear to have been reported in or near the Channel Islands, either then or around April 23, but it seemed possible to us that the Channel Islands area might be connected to the Kent coast area by this system of Channel faults and that associated tectonic stress might have built up in the underlying rocks near the Hurd Deep prior to the Folkestone earthquake.

We also found varying opinions about this. We asked the opinion of Dr Roger Musson, British Geological Survey, who replied that he was not aware of EQLs occurring at such a great distance (330km) from a quake hypcentre and doubted the connection because of the small fractured volume in this case (order of $1km^3$).[150] However Freund told us that stress can accumulate at 300km from the fracture and that it is very hard to place boundaries on the distribution of underground stress.[151] A study of the Saguenay EQL reports indicates 4 observations at ranges >160km, 2 at >200km.[152] Freund regarded a tectonic origin as plausible in terms of his p-hole process, but "whether or not this situation is applicable to the reported sightings . . . of course I don't know".[153] John Derr discussed the sighting report with Freund and with Canadian EQL experts St-Laurent and Theriault, and was more optimistic: "I think we agree that the sighting is highly likely to be precursory EQL," he told us, "and may lead to new insights into the mechanism of generation of these lights."[154]

We also looked for historical anecdotal evidence that local tectonic conditions might be favourable for EQLs. We could only find one EQ-related story,[155] recorded in 1843.

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[150] Email from Roger Musson to Jean-Francois Baure, 25.06.07
[151] Email from Friedemann Freund to Jean-Francois Baure, 22.05.07
[152] St-Laurent, France, 'The Saguenay, Quebec, Earthquake Lights of November 1988 - January 1989.' *Seismological Research Letters,* 71, no. 2, p. 160-174, 2000
[153] Email from Friedemann Freund to Martin Shough, 25.05.07
[154] Email from John Derr to Jean-Francois Baure, 08.06.07
[155] Although other reports of strange lights exist of course. For example, a 3-minute 1975 pilot sighting of "orange lights" moving at ~500ft off the coast of Guernsey was reported in an MoD signal sent to the Defence Intelligence office DI55 on 09 Oct 1975:

> From MODUK
> A 3 mins 090632A
> B 4 separate orange lights
> C both pilots of Herald aircraft on approach - land runway 09 Guernsey approach
> D naked eyes
> E between Guernsey and Jersey moving south or SW

At 7:30 pm on Dec 20, 1843, a "very remarkable meteor" was seen in the sky of Guernsey, a luminous body "like a clouded moon" moving slowly for 10-15 minutes. Two days later at 3:00 in the afternoon the hitherto bright sky filled with clouds that were strangely coloured with tints of green, red and purple. At 3:50 an earthquake struck, shaking buildings, ringing church bells and causing minor damage, whilst a loud undulating rumble was heard all over the island.[156]

One issue of possible relevance to the EQL theory is that our UAPs would apparently have been located over the ocean. In terms of some EQL theories this might be problematic. For example, friction heating or piezoelectric corona discharge would seem to require a rock-air interface to generate luminous bodies in the atmosphere. In any electron charge migration theory there is already a difficulty with the transport of sufficient charge to the surface of exposed rocks. Conceivably sparking stress fractures in rocks under the sea bed could emit radio waves, but these would be blocked or drastically attenuated[157] by the overlying volume of water.

The recent p-hole theory of Freund has attracted attention largely because it offers a promising alternative mechanism of charge migration in rock.[158] This mechanism is, as he explained to us, "relatively trivial"[159] and probably could not circumvent the problems of more conventional

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F objects at all times appeared to be lower than the Herald aircraft which was at 2,000 feet. They were possibly at 500 ft. The objects, which gave the impression of being in a line were not more than 5 or 6 miles away and tracking down the east coast of Guernsey.
K Guernsey a/f
L Guernsey ATC
M -- ----------- Teddington MX 15 years experienced pilot
O -- -------------
P 090730
Q Yes
Distribution: S4(Air) action; DI55; DI13d; Ops(GE)2; Science 3
Not followed up

The signal was discovered recently by David Clarke during research at the National Archives, Kew (TNA ref DEFE 31/171, file ref D/DI55/1/15/1 Pt 9). We were unable to find a record of any seismic event in the Channel area near this date.

[156] Falla, G., The Remarkable Guernsey 'Meteor' and Earthquake of 1843, BUFORA, Aug 2007 .http://www.bufora.org.uk/Default.aspx?tabid=72
[157] The extremely low (order of 10Hz) electromagnetic frequencies that are not quite effectively blocked by water carry very little energy and to get enough of it through the conductive water blanket seems difficult to say the least. Electrical breakdown causing corona discharge glows needs hundreds of thousands of V/cm at rock edges and corners. Such gradients seem unlikely to arise from million-metre ELF waves weakly reaching the atmosphere over a huge surface area of ocean.
[158] The "holes" are defects in the negative electron structure of the crystal which can be treated as positive charges.
[159] Email to Martin Shough from Friedemann Freund, 25.05.2007 "If positive hole charge carriers are activated in an otherwise insulating dielectric medium, they throng to the surface. They build up a surface potential from which we can calculate the electric field. If the concentration of positive holes is sufficiently high, the field can easily exceed 500,000 V/cm, even on a flat surface, a value that invites speculations that air molecules should become ionized (field-ionization, loosing an electron to the surface and become airborne as positive ions). About ten years later [c.1994] I was able to experimentally show that this effect takes place and leads to luminous effects emerging from edges and corners of rocks due to corona discharges in the air."

corona discharge theories in the case of an EQL over water. However there is a second and more intriguing possibility "based on observations which suggest that the wavefunction associated with positive hole charge carriers is not localized on any one oxygen anion but spreads out over many oxygen anion positions, maybe as many as several hundred. If the number density of p-holes reaches a threshold . . . the wavefunctions will begin to overlap and the system will undergo a transition from a weakly doped semiconductor state to a highly doped (quasi-metallic) plasma state. I have 'seen' this transition in a number of experiments . . . ."[160]

The relevance of this mechanism to the Channel Islands UAPs is the possibility that a rapid build-up of tectonic stress in a small source-volume of the Earth's crust may lead to such a plasma state which becomes unstable and "bursts" outward through the surface. Freund speculates that some EQLs are such p-hole plasmas, and in answer to our questions he opined that "a shallow body of water would not be an impediment (I think) to the outburst of the plasma bubble". However he cautions that it is only "a plausible physical process (untested yet) that could explain part of the story" and there is as yet neither a theoretical nor an experimental basis for saying that large, stable, luminous shapes at altitude can be caused by such plasma outbursts - if indeed they occur.[161]

This theory raised some further questions in our minds. An unstable plasma propagating rapidly outward through the rock from the source volume would, one imagines, prefer to travel as an expanding wavefront of p-type plasmons radiating from this "hypcenter" to the "epicenter" (of the wave, not the quake), leading to a diminishing surface potential spreading outward from the epicenter. In this case the energy density at any region of the surface must be a tiny fraction of that at the source, in a short pulse, with a tendency to dissipate further in the air. We wondered how the stability and somewhat high energy density implied by the idea of a "plasma bubble" EQL might arise from the unstable dissipative process of a p-hole wave generated deep underground. What secondary mechanism(s) might be at work? Is it possible that the process recyles sufficiently fast to keep the EQL pumped, and if so is it possible to guess at the frequency? And/or is some sort of focusing mechanism possible owing to the underground configuration of charge carrying rocks?

Prof. Freund replied that the answers to such questions are largely in the realm of speculation at the moment, but offered this very interesting suggestion[162]:

> I know from my lab experiments that pholes can (i) be activated in every igneous and high-grade metamorphic rock that I have had a chance to study in at least some detail, and (ii) propagate through such rocks. I also know that pholes cannot be activated in regular technical glass (window glass), but they can propagate through glass. However, pholes can neither be activated in marble nor propagate through marble. The reason (for which I have rather convincing crystallographic arguments) is that the structure of Ca-carbonate, the mineral calcite in marble, does not support the formation of the parent defects out of which pholes can be activated. What is true for Ca-carbonate must be true for other carbonates as well, in particular for Mg-carbonate magnesite, which is often (I have been told) associated with magmatic lamprophyres. Therefore the idea came up that the

[160] *Ibid.*
[161] *Ibid.*
[162] Crediting the original idea to Robert Theriaux in discussion with himself, France St-Laurent and John Derr.

> presence of lamprophyric dykes in the deep underground could constrain or 'focus' the flow of pholes in such a way as to more easily achieve the critical density necessary for entering into a plasma state. It would certainly be a worthwhile task to inspect geological maps of those places where EQLs have been observed whether there are any magmatic or sedimentary carbonates in the neighborhood.[163]

We found out that lamprophyres are indeed present throughout the geologically-connected area (northern edge of the Massif Armoricain) containing north Brittany, Contentin, and the Channel Islands. All of the islands (with the exception of little Sark) contain lamprophyres.[164] These are relatively young rocks dating to the period of "Variscan plutonism" about 280-345MY ago and presumably overly many of the older igneous and ancient basement rocks, but we have not found a precise map of the distributions.

It is possible that at least one of the triangulated UAP locations could have been close to the Casquets Rock, a small islet west of Alderney bearing the Casquets Lighthouse. What, we wondered, might be the effect of a p-hole wave reaching a rock/ocean boundary which is penetrated by an isolated rock/air discharge point in the form of an island - or nearly penetrated by a submarine seamount? How does the wave of positive holes behave when reaching the water, i.e. what possible ion transfer effects are there involving dissolved salts at the interface, and what happens *a*) in the deep region and *b*) at the rising seafloor around the island? Is it possible that the discharge-to-air route is a preferred minimum energy path and that the seabed potential is shunted towards the island, so that the island acts to "collect" and concentrate the current from a wide area?

We were unable to find clear answers to such questions, although it seems likely that "the dielectric properties of the medium will play an enormous, if not controlling role in the 'bursting' of the bubble".[165] The p-hole theory is not yet well enough developed to predict where and in what form EQLs might be observed, even if the local geomorphology and seismic conditions were known in detail. But it is an intriguing possibility, and the proximity to the Alderney-Ushant fault, the probable presence of lamprophyre dykes in the vicinity, and the significant Kent earthquake just a few days later, are all at least circumstantial evidence. It also seems possible that an aerial plasma of this type would have a small radar cross-section at the centimetre wavelengths of ATC and weather radars (see *Section 4*).

It is worth listing some of the negative indications: The persistence of UAP#1 for at least 12min; stability of form for 12min; "very sharply defined" binocular outline; extreme brightness in strong daylight (typical EQLs are not perceived as brilliant even at night, but as aurora-like glows); anisotropic luminous output (pale "yellow/beige" from the south; "very brilliant" from

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[163] Email to Martin Shough from Friedemann Freund, 26.05.2007

[164] C. J. D. Adams, 'Geochronology of the Channel Islands and adjacent French mainland', *Journal of the Geological Society* 1976; v. 132; p. 233-250; esp. Table 1, P.235 http://jgs.lyellcollection.org/cgi/reprint/132/3/233?ijkey=03c9785c0a1bc38bc62d68b32898e198222c8d36

[165] Email to Martin Shough from Friedemann Freund, 26.05.07: "Depending upon the dielectric constants of the rocks in the deep underground, a propagating wavefront can be expected to be diffracted and/or focused in a way that I don't even begin to understand. The fact that liquid water has a high dielectric constant of 81 (versus epsilon of rocks being more in the 6-10 range), will certainly also have to enter into consideration."

the north[166]); yellowish or yellow-orange colour (blue or purplish colours - the colours of corona discharge - seem statistically favoured); apparent immobility for the whole observation period; all of the above duplicated in an identical (apart from angular size) UAP#2 for at least 6min; the "graphite grey" bands at the same position on each object; distance from dry land (in at least one case) by several nmi and 1500-2000ft of altitude.

We are aware of no well-authenticated observation of EQL that reproduces even a few of these features. But given that the nature and mechanism of EQL is at best obscure it does not seem possible to do more than define the class of EQL phenomenologically, rather than physically. This being the case one does not know *a priori* whether a given observation should be excluded from the class or included to redefine the class. It is certain that reports of many types of aerial phenomena exist that find no comfortable home in any classification today but may do so in future.

On this basis, and with a view to the striking coincidence of the Kent earthquake as well as the local geology, we cannot rule out novel EQL-related effects in this case.

Plausibility (0-5): 3

l) earthquake clouds

Finally, we should mention the subject of so-called "earthquake clouds", which it is probably fair to describe as very controversial.[167]

It is claimed that there is a significant association between imminent earthquakes and the presence of certain types of clouds which are anomalous in terms of the local weather. It has been claimed that satellite observations of these EQ clouds can even be used as a reliable predictor of major earthquakes. The causal connection is said to be the venting of superheated subterranean water vapour, and the resulting clouds are characteristically "line shaped" "snake shaped" or occur in groups of "parallel lines", the linear features sometimes occurring inside large voids in the surrounding weather clouds.[168]

Our impression is that some of the cited "EQ clouds" inside voids might be explained as ice-fall clouds or so-called "hole punch" clouds (caused by ice crystals falling from higher altitude - possibly from jet contrails - into supercooled altocumulus layers and triggering spreading

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[166] Note that Capt Patterson was initially unable to see anything, even when some 6nmi closer to the triangulated location of UAP#1. At this time the depression angle from the Jetstream to UAP#1 would have been ~5.0°, reducing at the sighting time to about 1.1° (UAP #2 would initially have been almost directly below the aircraft, latterly falling almost directly behind.). It is not known whether the visibility of some type of EQL emission might be sensitive to the elevation angle (and/or bearing angle) of viewing. Capt Bowyer's viewing angle remained much less than 5.0° (visually estimated max. -2.0° depression; calculated max. [*Sect.3, Fig.8*], 1.1° below geometrical horizon, reducing through 0° to about +0.5°).

[167] Zhonghao Shou, *Earthquake Clouds; a reliable precursor,* Science and Utopya 64, pp.53~57, October 1999. See: http://quake.exit.com/index.html

[168] Harrington, Darrell, and Zhonghao Shou, 'Bam Earthquake Prediction and Space technology', Earthquake Prediction Center, New York. http://quake.exit.com/copies/BamSeminars.pdf

precipitation; the whisps of fall-out or *virga* often form a linear feature before melting and disappearing as can be seen in many photographs[169]). Other linear clouds may be ship trails (see *Section 6.f*) or wave clouds (*Section 6.g*). Nevertheless, an EQ prediction success rate is claimed on the basis of unusual clouds, and steam eruptions have occurred in some major quakes.

Even if there is a tectonic connection between the Channel Islands geology and the 27 April Kent earthquake there are better attested types of precursor - and more appropriate for our purposes - than earthquake clouds (see *Section 6.k*). No earth movement was recorded in the sighting area. In any case the likelihood that hypothetical steam venting could be relevant to the UAPs seems remote, for some of the same reasons that apply to ship trails, a/c contrails and lenticular clouds.

Plausibility (0-5): 0

[169] See many examples at http://wkrg.com/weather/article_education/hole_punch_clouds/4097/ including remarkable satellite photos. Or http://apod.nasa.gov/apod/ap040112.html for a nice example photographed over Mobile, Alabama, and another here http://rustybucket.blogspot.com/2004_09_01_rustybucket_archive.html over Woodford, England.

7) Conclusions

We have rated the plausibility of sixteen different hypotheses on a scale of 0-5. These ratings are of course a matter of judgment based on balancing sometimes complex arguments and counterarguments. Other analysts may disagree with our ratings and conclusions. The sixteen hypotheses have been ranked as shown in the table in *Fig.38*.

Rating	Hypothesis
0 very implausible	**sundogs** **subsun,** **3rd/4th order rainbows** **windscreen reflections** **earthquake clouds**
1 somewhat implausible	**god-ray patches of sunlight on the sea** **sunglitter reflections from lakes in Brittany** **aircraft contrails** **ship tracks** **military exercise** **lighter-than air vehicles**
2 barely plausible	**sunglitter reflections from the sea off Brittany** **direct specular reflections from Guernsey glasshouses** **lenticular clouds**
3 somewhat plausible	**specular glasshouse reflections scattered from a haze layer** **earthquake lights**
4 very plausible	**none**
5 definite identification	**none**

Fig 38. Ranking of 16 hypotheses

We judge that "very plausible" (Band 4) would count as a successful explanation for all practical purposes. Notably, Bands 4 and 5 are empty. That Band 5 is empty is not so surprising, but we might have hoped for something in Band 4.

Two theories stand out by making it to Band 3. Both of these have significant problems keeping them out of band 4. The rating “somewhat plausible” as applied to these two Band 3 theories (specular sun reflections on the haze layer from Guernsey greenhouse glass, and earthquake lights) means that they are attractive in terms of some significant features of the observations, but are still counterindicated by some other significant features. We regard a “significant” feature as one which we ought to require a good reason to discount.

In summary, we are unable to explain the UAP sightings satisfactorily without either *a*) discounting at least some significant features of the reports, or *b*) doing violence to at least some conventional meteorological optics or conventional EQL phenomenology. We hope that readers of this report will find it helpful in deciding which (if either) of those courses of action seems the more reasonable and economical.

Discussion

We have undeniably found some evidence suggestive of an atmospheric-optical explanation. In general “atmospheric-optical” means some effects on the propagation of light either by airborne particles (haze, mist or ice crystals) or by refractive index anomalies (unusual temperature gradients, causing mirage).

Unusual ice-halo effects are ruled out by the absence of ice in the line of sight. But there was a haze layer below the aircraft, probably associated with a weak temperature inversion in the CI area. That inversion would be the remnant of a much stronger advection inversion near the Breton coast, beyond the normal horizon, which was probably strong enough to form a localised optical duct.

Given the finding of a possible mirage-producing duct near the French coast one might feel that this cannot reasonably be a coincidence, and that mirage of sun-glitter on the sea near Brittany really ought to be a clear favourite. But we have placed this theory in Band 2 (barely plausible). Why?

- The gravity wave direction appears to have been near transverse to the LOS from the Trislander, and the wave slope negligible. However, the capillary wave orientation and capillary wave slope distribution are crucial factors in formation of a sun glitter pattern. Meteorological evidence suggests some likelihood of a sea breeze development, that may have generated near-shore surface winds parallel to the LOS from the Trislander (favourable orientation for transverse capillary crests despite adverse gravity wave orientation) by about 1400UTC; but low wind speeds of ~2 m/sec would suggest only a small tail of favourable ~20° slopes in the capillary slope distribution.

This evidence is inconclusive but we cannot rule out a bright sun glitter pattern - perhaps aided by atmospheric-optical focusing or compression. However we find it unsatisfactory that

- the theory offers no interpretation of Capt Patterson’s sighting;

- it is not easy to understand how the theory accounts for the sharp-edged outlines and "dark bands" of two identical reflection patterns several km apart (1° at ~150km = 2.6km).

But these objections are perhaps not fatal, and it might seem justifiable to set them on one side for the sake of promoting the theory at least to Band 3 (somewhat plausible). The really serious problem is

- that during the course of 6 minutes Capt Bowyer observed the two UAPs steadily cross each other from left to right, horizontally, over an arc of a few degrees.

We are satisfied that there is no refractive index mechanism in the literature - even of a very speculative nature - that would begin to explain this, and that it is a significant feature of the report which we have no good reason to dismiss.[170]

Which presents us with the classic dilemma of eyewitness evidence: What is its weight, balanced against conventional scientific models of the world? In this case we can get rid of a major problem, and have an interesting but unchallenging mirage, if only we disregard the description of the two identical images crossing laterally. This is one of those "significant features". Do we have a good reason to ignore it? Our position is that *ad hoc* trimming for the express purpose of "saving the phenomena" is not a good enough reason unless alternative explanations that do not require trimming can be ruled out as unacceptable on other grounds.

In judging whether it is good method to scrap significant features of the observation other factors come into play, such as the internal consistency of the *prima facie* sighting geometry in *Section 3*, where by respecting the reported lateral motions we find

- a consistent set of sightlines from the Trislander to a pair of locations in the Alderney-Guernsey area including the correct parallax due to the aircraft motion,
- relative angular sizes of the two UAPs consistent with the distances to these locations,
- the correct ratio of changing angular sizes
- and a UAP#1 location consistent with an independent sightline from an observer on a near-reciprocal bearing (obviously neither the localised Breton inversion to the S nor sun-glitter reflection are relevant to a sightline looking N from near Sark).

A mirage - even a scientifically unknown "lateral mirage in the free atmosphere" - doesn't explain these things in a natural way, whereas something like reflections on local haze, or lenticular clouds, or EQL in that area, could do so. And although Capt Patterson didn't see a high-definition object, he did see something of the right sort of shape and size and colour in the

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[170] Only Capt Bowyer had an extended, uninterrupted view from the pilot's seat. Kate Russell, seated several rows back, had two shorter sightings, the first of perhaps 1 minute duration, the second of around 25sec. She also saw a relative motion of the two UAPs. Between the two sightings "the one above water [UAP#1}seemed to have moved" (*Appendix B.v*). Kate did not notice any relative motion *during* either sighting however. This may be explained by their brevity and by the witness's focus of attention during an unexpected event. The motion of ~3° in 6 minutes indicated by Capt Bowyer would correspond to an average rate of approximately 0.5°/min, or 0.5arcmin/sec. This would permit a relative motion of about ⅕ the width of UAP#1 during the second sighting and perhaps ½ the width of UAP#1 during the first sighting (assuming a constant rate). It therefore wouldn't be surprising if Kate *had* detected relative movement at least during her first sighting, if not the second. She did not. Nevertheless a relative displacement was noted between the sightings.

right place at the right time at the right apparent altitude (independently estimated), the like of which (he said) he had never seen before. It would certainly be preferable to take account of this sighting, too, if at all possible.

And preferring the haze-scattering theory does not mean that the potentially mirage-causing inversion on the Breton coast is a mere coincidence. The coastal advection duct is connected with the same warm NNE airflow producing the weak CI area inversion and the associated haze layer, so the coastal inversion *is* an indirect but necessary component of the haze-scattering theory, even if the light rays reaching the observers have not passed through that part of the atmosphere.

We think it would be exciting to be able to claim evidence of a completely new type of refractive index phenomenon, but we wish to emphasise that a mobile lateral mirage of the type implied would require horizontal temperature gradients of a severity and stability that seem inconceivable in the free atmosphere. Before adopting such a lateral mirage as a favourite one would wish to have ruled out the haze-scattering theory, the theory that observers were mistaken, *and* all other possible theories - including those that we have not yet thought of.

We are not convinced that the observations were mistaken, although we accept that this can never be ruled out by any objective test short of conclusively proving the presence of some phenomenon that explains them. During our investigation the overall cohesion and reliability of Capt Bowyer's account (in particular) has been tested in various small ways and it appears to us to have been careful and reliable. We think it possible that the UAPs did behave as described. This being so, we believe that the haze-scattering theory and the EQL theory are interesting alternative possibilities which could repay further study by experts

Speculations

An alternative would be to propose an entirely "new" phenomenon tailored to preserve all significant features of the sightings, possibly having no physical connection to atmospheric optics or EQL. Although we think this is much less likely, and is arguably less economical,[171] we cannot rule it out.

It is interesting that both of the theories we consider to have at least some potential to lead to an explanation are theories that place light-emitting or light-scattering phenomena of some type close to the triangulated locations in the Channel Islands area. To some extent this reflects the internal consistency of the *prima facie* sighting geometry (*Section 3*) and the sighting on a near-reciprocal bearing from the *Jetstream*. But the result does not depend on it. A major obstacle to

[171] Occam's Razor advises against invoking "new entities" where existing entities suffice. Defining "new" is fraught with ambiguity in an area where "existing" entities (for example, EQL phenomena) are themselves speculative, poorly understood and only tentatively (not universally) accepted on the basis of observational data often less well established than those here being assessed. EQL remains largely a phenomenological category rather than a physical category (see *Section 6.k*) and is perhaps best thought of as a small core of cases surrounded by a less well-defined periphery of related accounts of "earthlights" merging into folk tales (see, e.g: Devereux, Paul, *Earthlights*, Turnstone Press, 1982). The same can be said of "ball lightning" (BL), and, to a much greater extent of course, of "unidentified flying objects". The phenomenological differences between sub-groups of these categories may sometimes be small compared to their internal variation, suggesting that there are sociological origins for these ambiguous boundaries, which are overlaid on - and possibly act to obscure - physical ones..

any mainly atmospheric-optical theory - such as mirage or mock-mirage of sun reflections beyond the horizon - is the lateral displacement of the two similar[172] images relative to one another, and even more importantly their steady lateral motion relative to one another, over an arc amounting to perhaps 3°. This behaviour is very explicitly reported and we can find no justification for discounting it. But we are unable to find any reference for an atmospheric-optical mechanism, even a speculative one, that could explain it. On the other hand, this behaviour would be quite naturally explained by parallax in terms of the *prima facie* sighting geometry permitted by placing phenomena (such as the two Band 3 phenomena listed) in the triangulated locations.

At the same time, there are historical accounts of observations that do appear to invite atmospheric-optical explanations but are beyond the abilities of any known mechanism to explain. A possibly relevant example is the remarkable "double sun" discussed by Minnaert.[173] A photograph allegedly taken by a passenger from the deck of a ship in the Indian Ocean shows the sun near the horizon in clear air with, beside it, a second sun, a perfect duplicate image at precisely the same elevation over the horizon. The story is that this was witnessed by 20 or 30 other passengers. We are not aware of any proper explanation of this phenomenon in terms of conventional atmospheric physics. Physicist Philip Morrison[174] dramatised the problem by pointing out that the effect might be simulated by suspending a gigantic sheet of flat plastic at the proper angle over the sea about 1000yds from the vessel. If the report is credible[175] there seems to be no possible explanation other than an extraordinary ice-halo reflection.

A dissimilar phenomenon but one inviting the same sort of speculation is the group of UAPs observed by crew and passengers of a BOAC Stratocruiser at FL19 near Goose Bay, Labrador, on a June evening in 1954. This event has some interesting similarities to the Channel Island UAPs.

In this case a linear array of dark shapes was seen that appeared to climb into the clear from below a broken stratocumulus deck and remained visible silhouetted against the bright "silver" sunset sky off the left wing over a distance of 85nmi. One large object changed shape in a "jellyfish-like" manner whilst six other smaller ones, disposed either side of it, moved relative to it and to one another.[176] The UAPs appeared to remain close to 0° elevation relative to the aircraft and at the same bearing from the aircraft for 22 minutes (by lining them up against the cockpit window post the navigator noticed a small deviation at one point, but this could possibly have been due to yaw in the aircraft axis). They appeared to be about 5nmi away. Towards the end of the sighting the smaller shapes appeared to "enter" the larger, which then dwindled and vanished. The UAPs were apparently not seen from an approaching F-94 closing head-on with the Stratocruiser at 20nmi, and there was apparently no ground or airborne radar contact with the UAPs (although the F-94 did acquire the Stratocruiser on its airborne radar at that range).

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[172] In the mathematical sense, i.e., identical except in terms of angular scale.

[173] M.G.J. Minnaert, *Journal of the Optical Society of America*, 58 (1969): 297.

[174] Morrison, P., 'The Nature of Scientific Evidence' (1969 AAAS Symposium), in: Sagan, C. & T.Page (eds) *UFOs-A Scientific Debate*, Cornell U.P. 1972, p.287.

[175] It's reasonable to point out that the chain of evidence is rather weak in terms of the standards generally applied by scientists to reports of 'unidentified flying objects', for example. It is not clear that a hoax or opportunistic prank can be ruled out. A reflection in window glass might produce the same novel effect, and the "20 or 30 other witnesses" have probably not been traced and deposed under oath.

[176] An account by the pilot, Capt Howard, showing drawings of the phenomena taken from his logbook was published in *Everybody's Weekly*, 11Dec, 1954. http://www.ufocasebook.com/1954ufomothership.html

Thayer[177] comments that "certain facts in the case are strongly suggestive of an optical mirage phenomenon" but adds that the persistence of the display at the same bearing over 85nmi would be "quite unusual" for any mirage. This seems a little understated! Capt Howard was certain that the UAPs were solid objects, not mirage images, and they were seen at first moving "in and out of a broken layer of stratocumulus cloud. As we watched, these objects climbed above the cloud . . . ." If accurately described this behaviour seems most unlike optical mirage. Nevertheless, we are inclined to agree with Thayer who finally places the report in "the category of some almost certainly natural phenomenon, which is so rare that apparently it has never been reported before or since."

Similarities with the Channel Islands UAPs include the extended visibility from a moving aircraft at an approximately constant bearing, horizontal motions of the UAPs relative to one another, confinement of the UAPs to within a few degrees of a horizontal plane containing the aircraft, and an apparent climb to the horizontal from a small depression angle.

But unlike the Labrador phenomena our UAPs were: Brilliant, not dark silhouettes; had stable, sharply-defined shapes instead of "jellyfish-like" fluid outlines; remained visible through 2000ft of altitude change; and were apparently also observed on a near-reciprocal line of sight from Capt Patterson's *Jetstream* far to the south.

None of these cases is very easy to explain by optical refractive index anomalies, but in the Channel Islands case it seems especially difficult (*Section 6.d*). Partly this is because of the difficulty of finding plausible light sources at distances that would not place severe constraints on the optical geometry of mirage or mock-mirage (*6.d.i, ii, iii & iv*), partly because of the duplication of identical very peculiar images, their rather well-defined steady lateral relative motion past each other, and the very wide-baseline triangulation of sightlines to UAP#1.

In the Labrador case lateral motions of the UAPs were observed, but of a rather chaotic kind, with the "about six" smaller objects seeming to switch about from left to right of the larger one in different patterns, whilst remaining approximately in a horizontal line. Finally they "suddenly vanished". The First Officer said it "looked as though" they shrank into the big "jellyfish" just before it began itself to dwindle in place, vanishing in a few seconds. It seems possible that such a display *might* be caused by some type of superior mirage, with looming and towering causing small silhouetted pieces of irregular terrain beyond the normal horizon to be lifted into view in a randomly changing sequence. Apparent relative horizontal motions in such a case could be an illusion as different parts of the skyline are selected in sequence by the optical duct.

On other hand, the Indian Ocean double-sun described by Minnaert involves a clear horizontal separation of two very well-defined, stable images. This is itself not explainable by any known mirage mechanism,[178] but at least the perfect image(s) do(es) not display any relative motion.

[177] Thayer, G.D, Optical & Radar Analyses of Field Cases, in: Gilmor, D. (ed.) Scientific *Study of Unidentified Flying Objects* (Condon Report), Sect. III, Ch..5, p.207. http://www.ncas.org/condon/text/s3chap05.htm#c1d

[178] Atmospheric scientist Andy Young suggests some very rare small-radius ice halo caused perhaps by an unusual crystal configuration, but agrees (emails to Martin Shough, 06.02.08) that a similar mechanism is ruled out in the case of the Channel Islands UAPs, because the freezing level was above 10,000ft and no line of sight from any observer to any possible light source can have passed through an ice crystal layer (see *Section 5* and *Section 6a & b*).

In the Channel Islands case, however, we have as it were the worst of both worlds: Well-defined, stable images with identical internal detail, separated both vertically and horizontally, *and* displaying steady relative horizontal motion. If it seems scarcely feasible to explain the double-sun as a kind of lateral "looming" due to sharp horizontal refractive index gradients, it is surely difficult even to imagine the atmospheric structure that would cause two such stable images to move steadily past each other and swap places laterally, never mind explain observations on near-reciprocal sightlines.

Nevertheless for completeness we did consider the possibility that such a very extraordinary structure - a sharp vertical layer of RI discontinuity approximately representing Philip Morrison's imaginary "plastic sheet" - located in the north Channel Islands area between the *Trislander* and the *Jetstream,* might in principle explain both the laterally-displacing UAPS seen from the former and the UAP sighted on a near-reciprocal sightline from the latter. The idea would be that the "yellow/beige" object seen by Capt Patterson was actually a mirage image of the bright yellow *Trislander*, at that time many miles to the N. If this intermediate structure could be imagined to act as an atmospheric one-way mirror, might it even be possible that the "brilliant yellow" UAPs seen by Capt Bowyer and passengers were reflections of their own sunlit aircraft? Capt Patterson indicated (*Appendix B*) that the colour of his UAP was not dissimilar to that of an Aurigny *Trislander (*see *Fig 36)* seen at the range of Alderney in conditions of haze.[179]

It was not hard to find problems with this speculation:

1) The bearing of the object seen by Capt Patterson ~2nmi to the W of Alderney is about 10° to the left of island. Angular and linear distance estimates may be unreliable, but Alderney is a non-negotiable back-stop: The UAP was to the left of the island. However the *Trislander* position proven by the radar plot at the time of Capt Patterson's observation (*Section 3, Fig.7*) was well to the right of the island. The angle between these bearings is about 25°. There is no known or conjectural mirage mechanism that can refract ray paths laterally by 25°, even fleetingly, never mind for a long duration. Horizontal deviations of only seconds of arc or possibly in extreme cases minutes of arc might occur due to horizontal temperature fluctuations, and this is just transitory image wander, like stellar scintillation.[180] The horizontal temperature gradients required are huge and completely unphysical. Even the strongest vertical gradients only cause bending (vertically) of <1.0°.

2) Towering of superior mirage can cause image enlargement, but of course only in the plane of refraction. Horizontal analogues of looming and towering are totally unknown and there is no mechanism for such. Refraction in two directions *orthogonal* to one another cannot occur in any case. A lensing effect like this would require the index of refraction to vary symmetrically around the line of sight. This is meteorologically unheard of, and such symmetry would anyway be inconsistent with the requirement to asymmetrically displace the entire image sideways by many degrees.

3) But let us suppose an unknown mirage mechanism capable of bending raypaths horizontally

[179] It's worth noting that the only large ship possibly in the area, the *Mv Bretagne* (*Section 4*), was painted not yellow but white, with some red trim. See http://www.brittany-ferries.co.uk/index.cfm?articleid=149

[180] In fact a couple of minutes earlier, when the hypothetical angle of lateral refraction would have been much closer to a favourable grazing angle, Capt Patterson was unable to see anything in the area (see *Section 2*).

through 25 degrees: The distance to the *Trislander* from the *Jetstream* is over 30nmi. At that range, even supposing the most favourable orientation (a side-view of the 50ft fuselage) the *Trislander* subtends about 0.01°, very tiny. But in reality it is almost nose-on, and at about the same altitude, so the aspect presented to *Jetstream* is the most *un*favourable, i.e. basically just the nose. (The wing section would be in the region of 1/10,000° thick at 30nmi, or in the order of 0.1 arcsec, which is smaller than the smallest visual angle detectable by the human eye in optimum laboratory conditions using a black line against a uniform bright background. The optical refraction cannot be invoked to fatten this horizontal wing section because our theory requires the ray bending to occur at 90° to it, right to left, not up and down.) So the available yellow area is (say) 10 feet of the *Trislander's* nose, which is less than 10arcsec at 30nmi, or about 1/260th of the diameter of the moon. (For comparison the disc of Jupiter is 30-45 arcsec, Mars and Venus around 15 arcsec.)

4) 10arcsec is about a factor 5 smaller than the threshold of detectability for a young non-myopic adult eye in ideal conditions. But Capt Patterson estimated that the object he saw (with the naked eye) was an oval or oblong shape which, by comparison with the island of Alderney, would have had a maximum horizontal dimension of about 0.5nmi at the same range. Alderney, in this perspective, would have subtended about 7° in width from 20nmni range, indicating an angular width of about 1.3° for the object, or more than twice the apparent diameter of the moon. He says this is a maximum possible size. When he estimates a comparison with a *Trislander* fuselage at the same range (~20nmi) he gives a smaller size, maybe 4 or 5 times the size of a *Trislander's* 50ft length, i.e. about 200-250 ft, which is about 0.1°, or 1/3 the diameter of the moon. The direct angular scaling against the adjacent island is in our opinion likely to be the more reliable. In any case, the average of these rather wide brackets is something comparable to the diameter of the moon.

5) An atmospheric-optical explanation of the sightings by Capt Bowyer and passengers as a "reflection" of their own *Trislander* would require *at least* 100% efficient backscatter at near-normal incidence - "at least" because of the extreme near-specular brilliance of the yellow UAPs, much brighter than incoherent scattering from the *Trislander's* yellow paint could possibly be (the *Trislander's* windshield angle is ~50° away from the angle for specular sun reflection near 0° elevation). We imagine that this would add many orders of magnitude to the already outlandish refractive index gradients required by 1) above.

6) Even if a temperature domain wall with an amazing power reflection coefficient existed between the *Trislander* and Guernsey, we question whether it could simultaneously refract by 25° in one direction, whilst being perfectly transparent to rays passing unrefracted through it from the opposite direction. (The island of Guernsey was seen both behind and adjacent to the UAPs and appeared normal to Capt Bowyer.) It is also very unclear how such a phenomenon could explain two reflected images of the *Trislander* or their relative motions.

7) Our meteorological model shows a French coastal inversion decaying south of the Channel Islands and a small inversion (vertical gradient of course) of maybe 2 - 3°C/kft along the line of sight between the *Jetstream* and the *Trislander*, and capped by the 2000ft haze layer therefore below the altitudes of both aircraft. It seems to fit the general synoptic weather situation. Nothing in this model or the observations supporting it hints at even the remote possibility of anomalous vertical temperature domain walls in the atmosphere.

There are no doubt other geometrical and physical objections but in our opinion the above points suffice to render the notion completely unrealistic.

In summary, we have tried our hardest to explain the observations but none of the theories we have explored sits comfortably with *all* significant features reported.

An unusual mock-mirage of brilliant sun-glitter reflections from the sea near the French coast was considered, and might be worth the cost of discounting Capt Patterson's sighting were it not for Capt Bowyer's explicit description of lateral image motions. This feature is effectively impossible for mirage; even so, we put the theory in the category of "barely plausible" to acknowledge its other attractions.

We score two other theories as "somewhat plausible" because they seem to have potential to explain the lateral apparent motion as well as at least some, perhaps a majority, of the other significant features. These are

- *Secondary scattering, by a haze layer, of specular sunray reflections from greenhouse glass on Guernsey*
- *Earthquake lights*

But a potential to explain is not an explanation. It may prove possible for other investigators to adapt these theories and so improve the fit with observation, or further work might thoroughly rule out one or both of them.

Finally we note that either of these theories could be consistent with the apparent absence of unambiguous ATC or weather radar detection. But although we have found no evidence of such detection, as mentioned in *Section 4* the raw ATC radar data has not yet been thoroughly investigated to the point of ruling out all possibility of significant echoes.[181] Moreover, the complexity of the radar and software environment does mean that, in this case, absence of evidence would not necessarily be sufficient evidence of absence, so it may not be straightforward to exclude other theories solely on this basis.

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[181] We anticipate that this issue will be clarified in a forthcoming report by the French government agency GEIPAN. It is our informal understanding, as of the date of writing, that GEIPAN's analysis has not found any significant echoes in the area.

Appendix A: CAA documents the MoD case file

i) CAA Mandatory Occurrence Report (MOR)

The text of the MOR quoted below was enclosed with a reply dated May 10, 2007, from Sarah Doherty, Head of Safety Data Unit, CAA, responsive to an inquiry dated April 26, 2007. *(Courtesy of Kim Efishoff, NARCAP)*

> A/C Type : BN2a Trislander
> Flight Phase : Cruise
> Classification : Occurrences
> Occurrence Number : 200703486
> Occurrence Date : 23 Apr 2007
> Location : Alderney
> Location Info : 10NNE
> Events : Miscellaneous Non-AD Occurrence
>
> Pretitle :
> BN2T crew observed a stationary bright light ahead, thought to be a reflection from the ground. However, crew viewed the light through binoculars and observed a shape, similar to a B737 fuselage.
>
> Precis :
> The crew contacted ATC, who originally stated that there wasn't anything showing on radar. However, they then observed a primary contact. The crew and some passengers observed the bright lights again later in the flight. The shape was said to be bright yellow with a dark area nearer to one end.
>
> Number of Records : 1

CAA refused direct requests for access to other pilot or ATC documents forming part of the MOR submission. These were pursued instead *via* the route of Freedom of Information Requests to the Ministry of Defence.

* * *

ii) MoD FOIA Request

A number of requests are known to have been made to MoD under the provisions of the UK Freedom of Information Act by various individuals, including two of the present co-authors. No satisfactory direct reply was received to any request, up to and including this one lodged by us on15 May 2007:

> I would like to request copies of the pilot report document and any associated materials filed with CAA under the Mandatory Occurrence Report system, (Occurrence Number 200703486; Occurrence Date 23 Apr 2007; Location Alderney; pilot Capt. Bowyer, Aurigny), also any other report(s) or record(s) and associated materials from any other

aircrew, Air Traffic Control facility or other radar installation connected with the incident.

However a few days later in view of wide interest in the case MoD decided to publish a redacted case file on the internet, thereby responding to all FOIA requests indirectly.

* * *

iii) MoD incident file

The UK Ministry of Defence file on the incident was made available on the MoD website on about 20 May, 2007 as a.pdf file containing a 1-page internal letter, a 4-page facsimile *Report of Unidentified Flying Object* prepared by Channel Islands Zone Controller Paul Kelly, a 3-page *Air Incident Safety Report* prepared by Capt Bowyer, Aurigny Airlines, and a 1-page letter to CAA from Capt Patrick Patterson, Blue Islands Airways.

The MoD internal letter, dated 30 April, stated that no UK defence radar cover exists in the area, and that in the absence of evidence of a threat to the UK no further investigation action was contemplated. This letter is chiefly notable for the incorrect statement that "we believe the ATC radar at Jersey is secondary only and therefore unable to achieve a primary radar contact".

The contents of the MoD pdf file are reproduced below.

[redacted]

From: [redacted]
Sent: 30 April 2007 17:04
To: [redacted]
Cc: BOU-AFC-DACCS SO2; [redacted]
Subject: UFO report 23 Apr 07 -
Importance: High

[redacted]

Once again apologies for the delay in responding.

The position reported is outside of the UK radar coverage and in fact inside French airspace for air defence. We had no reports from the French that the object was seen or detected on radar. We believe the ATC radar at Jersey is secondary only and therefore unable to achieve a primary radar contact (if the object was capable of producing one). The contact was reported as stationary again making radar detection unlikely and no further reports indicated that the object had a heading towards the UK. Therefore, we conclude that there was no threat to the UK from this observation and will not be taking the investigation further.

Hope that is sufficient for lines for the possible press interest.

[redacted]

Fax from : [redacted] (No reply as no address, passed to ORS) 25/04/07 14:03 Pg: 1
([redacted] F.A.O. JULIE FOI 1

ENCLOSURE 57 NUMBER

REPORT OF UNIDENTIFIED FLYING OBJECT.

A. DATE : 23/04/07
TIME : 1409Z — 1418Z DURATION 9 MINS

B. DESCRIPTION OF OBJECT(S)

ONE OBJECT SIGHTED AT 1409Z DESCRIBED AS BRIGHT ORANGE/YELLOW OF 'PLANFORM' SECTION.

LATER UPDATED (WHEN CLOSER) AS VERY BRIGHT ~~OBJECT~~ YELLOW OBJECT WITH GAP IN LIGHT OR 'DARKER AREA' 2/3 OF THE WAY FROM LEFT TO RIGHT (VIEWED FROM NORTH)

SECOND OBJECT SIGHTED AT 1416Z. DESCRIBED AS IDENTICAL.
FIRST OBJECT DESCRIBED AS '737 SIZED' AT ESTIMATED RANGE OF 7-8NMS.

C. POSITION OF OBSERVER

APPROX 5-10 NM NORTH OF ORTAC ON R41 FL40.
OBSERVER WAS PILOTING A TRISLANDER SOUTHBOUND EN ROUTE TO ALDERNEY FROM SOUTHAMPTON.

LATER SEEN BY PILOT OF A JETSTREAM 41 ([redacted]) FROM A POSITION NE OF SARK BY APPROX 5 NM TRACKING SE TOWARDS JERSEY. AIRCRAFT WAS AT THIS TIME AT A SIMILAR LEVEL.

D. HOW OBSERVED

BY NAKED EYE AND BINOCULARS (PILOT OF [redacted])
NOTHING SEEN ON RADAR, WITH EXCEPTION OF AN ODDROP POSSIBLY RELATED TO ONE OBJECT. (STATIONARY OBJECTS ARE FILTERED FROM DISPLAY)

E. DIRECTION IN WHICH OBJECT FIRST SEEN

FIRST OBJECT SEEN 'IN 12 O'CLOCK' POSITION AT A POINT NNW OF ALDERNEY. (AS SEEN FROM POSITION NTH OF ORTAC - AS IN PART C)
LATER UPDATED AS IN THE VICINITY OF BURHOU NORTH OF ALDERNEY.

THE SECOND OBJECT (SEEN AT 1416Z) WAS SEEN AS WEST OF ALDERNEY APPROX IN VICINITY OF CASQUETS 8-10 NM WEST OF ALDERNEY.

AS VIEWED BY SECOND PILOT ([redacted]) OBJECT WAS IN DIRECTION OF ALDERNEY AT RANGE ESTIMATED AT 10 NM.
(SECOND OBJECT NOT SEEN OR MENTIONED - OBJECT WOULD HAVE BEEN FURTHER BEHIND ACFT)

F. ANGULAR ELEVATION OF OBJECT

OBJECT FIRST DESCRIBED AT SIMILAR LEVEL ie FL40.
LATER DESCRIBED AS 2000 - 2500'.
AS ACFT DESCENDED TO 2000' TOWARDS ALDERNEY THE OBJECTS 'DISAPPEARED INTO THE HAZE' ESTIMATED 1500 - 2000'

OBJECT NEARER ALDERNEY ESTIMATED BY SECOND PILOT ([redacted])
AT SIMILAR LEVELS.

G. DISTANCE OF OBJECT FROM OBSERVER

IN THE RANGE OF APPROX 25nm (AS FIRST SIGHTED) DOWN TO
ESTIMATED 7-8 nm.

ESTIMATED 10nm FROM SECOND PILOT ([redacted])

H. MOVEMENTS OF OBJECT

OBJECTS APPEARED STATIONARY.

J. MET CONDITIONS

EGJA 1350Z MET OB.
SURFACE WIND 200/06 V 150-240
CAVOK
TEMPS 14/11
QNH 1021 mb

K. NEARBY OBJECTS

NONE

L. TO WHOM REPORTED

D AND D CELL, LATCC (MIL)
TELEPHONE NUMBER GIVEN AT M.O.D. (WHITEHALL) 0207 2182140
MESSAGE LEFT ON ANSWERPHONE.

25/04/07 14:03 Pg: 2 Fax from : [redacted]

M. NAME AND ADDRESS OF INFORMANT

[redacted] PILOT – CAPTAIN [redacted]
MOB: [redacted]

[redacted] PILOT – ~~FIRST OFFICER~~ CAPTAIN [redacted]
MOB: [redacted]

CONTROLLER, JERSEY ZONE – [redacted]
(SELF)

N. ANY BACKGROUND INFO.

NONE

O. OTHER WITNESSES

[redacted] PILOT ([redacted]. SEE ABOVE.

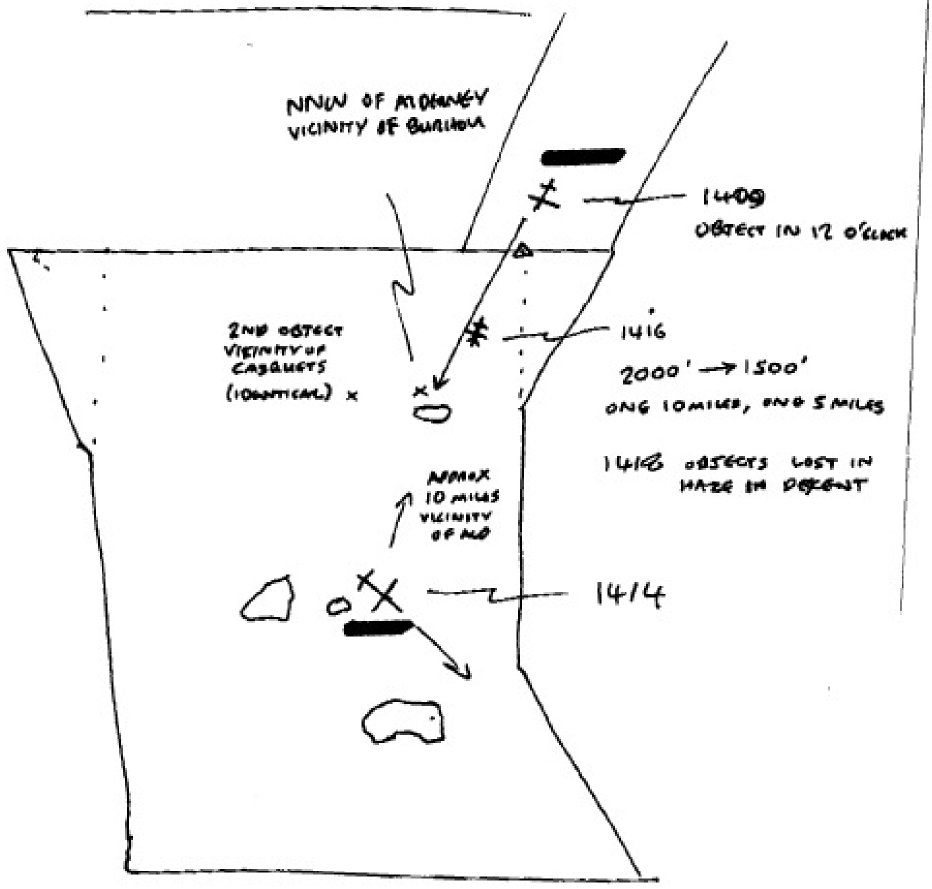
P. DATE AND TIME OF RECEIPT OF REPORT

TIMES AS STATED ABOVE.

COPY OF PILOTS FLIGHT LOG WITH DESCRIPTION AND DRAWING OF OBJECT RECEIVED BY FAX FROM [redacted] OPS IN ALDERNEY AT APPROX 1600Z.

Fax from [redacted] 25/04/07 14:03 Pg: 3

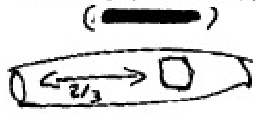
23RD APRIL 2007



EGJA MET
1350Z

200/06
150 V 240
CAVOK
14/11
1021

VIEWED FROM NORTH



VERY BRIGHT
YELLOW OBJECT
GAP IN LIGHT
2/3 OF THE WAY
FROM LEFT → RIGHT

POSSIBLY UP TO 737 SIZE

BOTH OBJECTS IDENTICAL

ALWAYS APPEARED STATIONARY

* THESE DETAILS AND DRAWING WERE BY
MYSELF FROM DETAILS GIVEN BY PILOT
AND PRIOR TO RECEIVING INFO BY FAX

25/04/07 14:03 Pg: 4

FAX FROM [redacted]

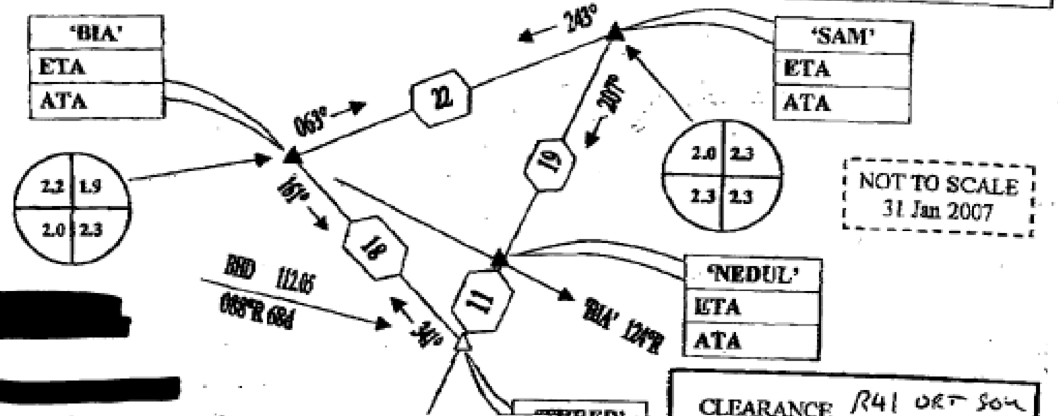
Fax from : [redacted]
23/04/2007

25/04/07 14:03 Pg: 5

Date	23.4.07	
Captain	[redacted]	
Reg	[redacted]	
Flight No	[redacted]	
Off Blocks	1226	1335
Take Off	1230	1339
Land	1318	1420
On Blocks	1320	1423
Total Block	0.54	0.48
Total Flying	0.48	0.41

Departure Fuel Calculation		
Forecast Wind	SW 8	
Fuel Required	69	72
Fuel on Board	76	106
Extra	7	34
Enroute Fuel Check		
Waypoint	ORTAC	THRED
Fuel required	30	31
Total Fuel	66	94
Extra	36	63

Notes Unidentified object seen. Bright yellow thin, stationary. Size of 737
2nd object same shape seen behind first at some distance
brilliant yellow
1400 Side 7-8 nms dark area 10 nm N Ortac 2-2500



[redacted]

Attn [redacted] please.

NB. After talking to [redacted] (capt):
1st seen 1400 } About 10nms N of
2nd seen 1410 } ORTAC @ c2-2500'

Drawing is side view at estimated 7-8nms

[redacted]

Airs Ops 23/4/7

ETA
ATA

CLEARANCE R41 ORT SOU
↗50 1242

7k 220/14/11
1020

MET 6k SW8 12/10
1021

7k ↑2000 ↗FL40 R41
ORT/ACI HDG Alliance 180°
7764

Captains Signature [redacted]

3 Apr 07 19:15 [redacted] Flt Ops p.2

[redacted]

AIR SAFETY REPORT

ASR No. 72C

1. Types of event (Tick all applicable)	ASR ✓ AIRPROX ○ BIRDSTRIKE ○ WVOR-TEX ○ GPWS ○ TCAS RA ○
CAA OCCURRENCE NO.	
2. LHS PILOT	[redacted]
RHS PILOT	—
JUMP SEAT OCCUPANT & STATUS	—
3. DATE OF OCCURRENCE	23/4/07
4. TIME (LOCAL/UTC*)	*DAY/NIGHT
5. FLIGHT NO.	GR 544
6. FROM/TO OR AT*	Sou / Aci
7. SQUAWK	7764
8. A/C TYPE	BN2 TRISLANDER
9. REGISTRATION	[redacted]
10. CREW/PASSENGERS	
11. TEMPERATURE *OAT/SAT/TAT	
12. TRAINING FLIGHT	YES/(NO)
13. ALTITUDE *QNH/AAL	FL 40 / FT*
14. SPEED *(IAS)/TAS	130
15. A/C MASS	4200 KG
16. SECTOR RECORD PAGE No.	
17. FLIGHT PHASE	TOWING — PARKED — PUSH-BACK — TAXI-OUT — TAKE-OFF — INITIAL CLIMB — CLIMB — (CRUISE) — (DESCENT) — HOLDING — APPROACH — BELOW 1500FT — LANDING — TAXI-IN
18. AIRPORT / STAND	
19. GEOG POSITION	10 NM NNE ACI R41
20. CONDITIONS	(DAY) NIGHT; IMC (VMC) 10+ km*
21. SURFACE WX	WIND / VIS km / CLOUD / TEMP °C / QNH mbs 1021
22. SIGNIFICANT WX *MOD/SEVERE	RAIN / SNOW / ICING / FOG / TURBULENCE / HAIL / STANDING WATER / WINDSHEAR
23. RUNWAY	RVR — m
24. RUNWAY STATE *	(DRY) / DAMP / WET / CONTAMINATED (ICE / SNOW / SLUSH) BRAKING ACTION :
25. CONFIGURATION *	AUTOPILOT ENGAGED (YES)/NO; GEAR UP/DOWN* / FLAP POSN

26 EVENT, CAUSE, ACTIONS AND RESULTS

During the cruise at FL 40, I noticed a bright light ahead which I thought was the reflection from the Sun off of glass in Guernsey. However, the light continued so I looked at it through binoculars (7x10). I saw a shape as per the diagram showing brilliant yellow with a dark area towards the right side as I looked at it. It appeared stationary. I asked ATC for any contact. Initially they said no then later said they had a primary contact in the area.

27 OTHER INFORMATION AND SUGGESTIONS FOR PREVENTATIVE ACTION

As the flight continued I noticed a second shape exactly as the first but further away. A number of passengers aboard noticed the lights. The flight continued uneventfully to Alderney.

* DELETE AS APPLICABLE PAGE 1 OF 2

25/04/07 14:03 Pg: 6 Fax from [redacted]

3 Apr 07 19:15 [redacted] Flt Ops p.1

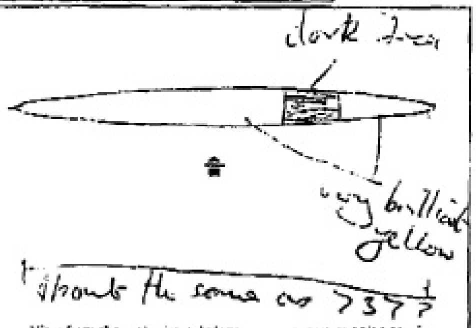
[redacted]

AIR SAFETY REPORT — Page 2 of 2

AIRPROX / ATC INCIDENT / TCAS RA / WAKE VORTEX / GPWS / BIRD STRIKE *

28 AIRPROX / ATC INCIDENT * and / or TCAS RA

Mark passage of other aircraft relative to you, in plan on the left and elevation on the right, assuming YOU are in the centre of each diagram. Indicate approx. scale.



View from above (horizontal plane : meters / NM *)

View from behind (vertical plane: feet)

SEVERITY OF RISK	LOW / MEDIUM / HIGH
AVOIDING ACTION TAKEN	YES / NO
REPORTED TO ATC	______ UNIT
ATC INSTRUCTIONS ISSUED	______
YOUR CALLSIGN	______
FREQUENCY IN USE	______
HEADING	______ DEG
CLEARED ALTITUDE	______ FT

MINIMUM VERTICAL SEPARATION	______ FT
MINIMUM HORIZONTAL SEPARATION	______ M / NM *
TCAS ALERT	RA / TA / NONE
TYPE OF RA	______
RA FOLLOWED YES / NO	(vertical deviation........ft)
WAS TCAS ALERT*	Necessary/Useful/Nuisance
(DESCRIBE ON PAGE 1 OTHER AIRCRAFT TYPE / MARKINGS / COLOUR / LIGHTING / CALLSIGN)	

29 WAKE VORTEX

HEADING ______ DEG — TURNING LEFT / RIGHT / NO

POSITION ON GLIDE SLOPE — HIGH / LOW / ON

POSITION ON EXTENDED C/L — LEFT / RIGHT / ON

CHANGE IN ATTITUDE (DEG) — PITCH__ ROLL__ YAW__

CHANGE IN ALTITUDE (FEET) ....

WAS THERE BUFFET? YES/NO STICK SHACK? YES/NO

WHAT MADE YOU SUSPECT WAKE TURBULENCE?

DESCRIBE ANY VERTICAL ACCELERATION

GIVE DETAILS OF PRECEDING AIRCRAFT TYPE (TYPE C/SIGN)

WERE YOU AWARE OF THE OTHER AIRCRAFT BEFORE INCIDENT?

30 BIRD STRIKE

TYPES OF BIRDS

NO. SEEN	1 ☐	2-10 ☐	11-100 ☐	MORE ☐
NO. STRUCK	1 ☐	2-10 ☐	11-100 ☐	MORE ☐
TIME	DAWN ☐	DAY ☐	DUSK ☐	NIGHT ☐

31 GPWS

RATE OF DESCENT ☐ FT/MIN

WAS WARNING CONSIDERED TO BE: FALSE / NUISANCE / GENUINE

NUMBER OF WARNING CYCLES ☐

WARNING MODE ASSESSED / DISPLAYED

ACTION TAKEN:

Give, under 26, additional information which is considered relevant e.g. possible effect of tailwind if Mode 1 or 2, deviation from GS if Mode 5

32 MOR

If you consider this event to be a Mandatory Occurrence under CAP382 please tick here and it will be forwarded to the Safety Investigations & Data Department of the CAA ☑

Signature

Print name [redacted]

NOW FAX THIS ASR TO AURIGNY OPERATIONS ON [redacted]

Pg: 7 14:03 25/04/07 [redacted] Fax from

24-APR-2007 15:26 From: [redacted] P.1/1

Copied to SATCO. 24/04/07

[redacted]

Jersey Airport
ATC

24.04.2007

Subject: Unidentified Flying Object NNW of Alderney
23.04.2007

[redacted]

[redacted] Jetstream 32, was inbound to Jersey from the Isle of Man approx. 1415Z. in the descent through ~3,500' Altitude, position five NM north-west of Sark when the pilot of an [redacted] Trislander called his position north of Alderney and asked ATC whether there was known traffic in his vicinity as he could see something in his 12 o'clock position. ATC replied that there was a primary return but that this was unknown traffic.

The pilot described the object as cigar shaped and having a yellow colour. Passengers on his flight were apparently also able to see the object. The pilot asked if any other aircraft in the vicinity could see the object.

I was in the left seat looking backwards towards Alderney and was able to see something fitting the description viz. yellow/beige in colour, in my eight o'clock position, slightly to the north-west of Alderney at what I estimated to be 2,000' below. Visibility was fairly poor due to haze. I estimate being able to see the object for about one minute. There were several interruptions due to flight-deck duties and when I looked again I had lost visual contact.

Hope this helps.

[redacted]

Pg: 8 25/04/07 14:03 Fax from [redacted]

Appendix B: Witness interviews and statements

i) Interview with Capt Bowyer, 08.06.07

Record of interview conducted by Paul Fuller at Southampton Airport on 8th June 2007, final version amended using Capt Bowyer's comments dated 8 July 2007, with added comments by Paul Fuller in square brackets. Paul has paraphrased Capt Bowyer's answers.

01 What is your full name?

Raymond Anthony Bowyer

02 How long have you been an airline pilot?

Ray has been flying since 1984. His first airline job was in 1989.

03 Which airlines have you flown for?

Numerous. Novair, Regionair, Channel Express, Jersey European, Fain Air Europe, Aurigny.

04 What aircraft have you flown?

Fokker 27, numerous other smaller aircraft, Trislander, etc. Ray has also conducted calibration work at airports for Hunting. PA 34 Navajo Aircraft.

05 Which routes have you regularly flown?

The principle routes over the past five years are Guernsey-Alderney, Alderney-Southampton, Guernsey-Jersey, Guernsey-Dinard [near St Malo, PF].

06 How many years have you been flying from Southampton to the Channel Islands?

Eight and a half years

07 How many trips would that have included? [Days per week?]

500-600 return trips.

08 Which aircraft were you flying on the day of your encounter ? [model and number]

Brittain Norman BN2 Mark 3 Trislander GXTOR.

09 How many years have you been flying that particular aircraft to the Channel Islands ?

Eight and a half years.

10 How long does the flight from Southampton to Alderney usually take ?

Around 40 minutes in still air.

11 What was the intended destination/route of this particular flight ? [with times of arrival/departure]

Southampton-Alderney-Southampton [Ray did not have his pilots logbook with him to check. The correct times are listed in the SRG report]

12 Is that the usual flight plan ?

Yes.

13 Who else accompanied you in the cockpit during this flight ? Did you have a co-pilot or a navigator ?

There was no-one else in the cockpit. Ray pilots the aircraft by himself. The passengers sit right behind him in an open cabin.

14 Did they see the lights as well as you ?

Yes. Ray thinks that up to nine of his passengers saw the lights.

15 What did they think of the lights ?

They were very interested. The fellow sitting behind Ray and Kate Russell saw two lights. [but the couple sitting behind him (the Russells) only saw one of the lights.] This may be because their view was more restricted than that of the man sitting directly behind Ray.

16 Where were you when you first saw the first light ? Please indicate on diagram 1. How does this correspond to the Channel Islands control zone shown on CAA Aeronautical Chart sheet 2171CD ?

Ray was about 60 nautical miles from Guernsey and about 15 nautical miles from ORTAC when he first saw the first light (Point A on Diagram 1). This point does not appear on the CAA Chart that David has copied to us. ORTAC is located on 50 degrees latitude but does not appear on any maps. At first Ray thought the first light was 10-15 nautical miles away (i.e. close to ORTAC) but later realised it was much further away – perhaps 50 nautical miles at point Z on Diagram 1.

17 How high were you when you first saw the first light ?

Flight Level 40, which is between 4,000 and 4,300 feet above sea level. Ray will need to check this because air pressure was slightly higher than average, he thought about 1023 Mb which would about 4,300 feet. [it says 1021 Mb on the SRG report - right hand side, PF]. 1021Mb = 4180 feet.

18 How fast were you travelling ?

Ray reported that he was cruising at 130 knots which is roughly 150 miles per hour which is crudely just over 2 miles per minute [actually about 2.5 miles per minute, ignoring wind speed, PF]

19 Can you give a precise direction for the aircraft ? Was this a straight line approach to Alderney ?

Yes, it was a straight-line approach after leaving Southampton Airport. The flight was on flight path Romeo 41 = radial 207 degrees [27 degrees west of due south, PF] – this direction is marked on the SRG diagram [which Ray says he has never seen before, PF]

20 Were you in level flight, ascending or descending ?

Level.

21 Was the autopilot engaged or were you flying the aircraft ?

The aircraft was on autopilot until Ray began his descent into Alderney.

22 Did you experience any clear air turbulence during the flight ?

None at all.

23 Could you see the horizon properly as you approached the Channel Islands ?

Yes, Ray could see the sea horizon clearly. There was a little bit of cloud around towards the east at the same level so that [horizon] was a bit obscured but it wasn't [obscured] in the direction of the object. Cloud overcast at about 8,000 feet.

24 Were you over land when you saw the first light ?

No. Over sea.

25 Could you see the Casquets Lighthouse ?

Yes, it was to Ray's right.

26 If so, where were these features ? Please indicate on diagram 1.

The Casquets Lighthouse was at Point C on Diagram 1. Unfortunately Ray's initial flight line covers most of the available paper so he has drawn Point C unrealistically close to Alderney.

27 How much cloud cover was there ?

To the east there was 3/8ths cloud cover. To the south/west/north there was 6/8s or 7/8s cloud cover with stratus overcast 8-10,000 feet with patches of thin cloud between (decompression). This cloud cover extended to 10 miles to the south of Guernsey. This equates to +6C on a standard day.

28 What kind of cloud could you see and at what level was the cloud ?

Ditto.

29 Was it raining or precipitating ?

No rain or precipitation.

30 How cold was it outside the aircraft ?

Ray would need to check his log book but believes it was “well above freezing” – about 10 degrees Celsius.

31 What was the wind speed and from which direction was it coming ?

Ray says this is in his pilot’s log book.

32 Where was the sun in the sky ?

Behind the clouds but virtually straight ahead.

33 Was the sun higher in the sky than you, at the same level or below you ?

Ray’s “pure guess” is that the sun was much higher in the sky – perhaps 40-43 degrees above the horizon. Well above the top of the windscreen.

34 At what time did you first notice the first light ?

Ray cannot be sure of the time but it is in his log. 3 minutes before the first call to ATC (log). The times he gave me were wrong. However, he was about 15 miles north of ORTAC.

35 How can you be sure that this was the correct time ?

Can’t be sure – it is in his pilots log book.

36 How bright was the first light in comparison with the sun ?

Ray couldn’t see the sun because it was overcast directly ahead. However he believes that the 1st light was a brilliant yellow like the sun. He wore no visor to protect his eyes but was not dazzled by the light and it did not hurt his eyes. It was a brilliant yellow colour and Ray believes it was light-emitting.

37 Did it appear to brighten or fade ?

No.

38 Did it flash on and off – and if so, at what periodicity ?

No.

39 What colour(s) did it exhibit.

With his naked eyes Ray could see that the first light was a brilliant yellow and that from left to right looking at it there was a "dark graphite grey" area about two thirds of the way along for 10% of the length.

40 Was the light to your left, right or directly ahead ?

Slightly to the right.

41 Was it above, below or at the same height as your aircraft ?

Initially this first light appeared at the same height as Ray's aircraft but just before he began to descend [i.e. he pointed the aircraft's nose downwards] he thought that the first light was slightly lower – perhaps by about 2 degrees. Described as a "shallow" angle. Ray explained that it is not always easy to judge this angle if the target is many miles away [e.g. due to curvature of Earth].

[My tape recorder stopped working from this point onwards – I turned it off temporarily as an aircraft taxied past the car and when I turned it on again it did not work – I have no idea why, PF]

42 Did it appear to have any shape when viewed with the naked eye ?

It was long and thin horizontally.

43 Did it appear to move or remain stationary ?

It was stationary or very slow moving.

44 In your CAA report and the press you were quoted saying that at first you thought the light was the reflection of some greenhouses on Guernsey. You then stated that it was not a reflection. On what basis did you reject this possible explanation ?

This reflection, which Ray has seen many times before, only lasts for 10-15 seconds "at most". [The "greenhouse" is actually a "vinery"]

45 Did your aircraft have an operating radar system and if so, did it indicate any target which might correlate with the first light ?

The Trislander has no radar system.

46 Please could you hold out your arm and estimate the visual angle subtended by the first light using this ruler. [not a British coin or a Euro] [measure Ray's arm length] [Could the light be compared with a feature on your windscreen?] [was there something on the windscreen to

protect your eyes from the sunlight?]

Ray's right arm length from shoulder to tip of his fingers is 75 cm. The first light subtended an angle of 6-7 mm when he first saw it but before the end of the sighting the light subtended an angle of 15-18 mm.

47 For how long did you observe this first light ?

Ray believes that he observed the first light for 12 minutes. It was about 3 minutes before he reported it to ATC.

48 How certain can you be that this is an accurate estimate ?

This estimate is based on memory. However, the CAA tapes should be able to confirm the 9 minute duration he was in contact with Jersey ATC.

49 How sharply defined was this first light ?

Very sharply defined throughout the whole of the sighting.

50 How long was it before you observed the light through binoculars ?

1.5-2 minutes from the start of the sighting [and before he contacted ATC, PF]

51 What was the power of the binoculars ?

Variable 730 x up to 15. Ray believes he used x 10 for most of the sighting.

52 For how long did you observe the first light through binoculars ?

10-12 minutes.

53 Was your impression that you were observing a bright reflected light or something that was emitting light ?

Emitting light.

54 Did this impression change when you observed the light through binoculars ?

No.

55 Please can you draw the first light as you first saw it, then as you saw it through binoculars. Please show any features or colours. This is diagram 2.

Top left shows light as seen with his naked eye. The larger light is what Ray saw through his binoculars. Both were " 'sunshine' yellow".

56 Was this object precisely defined or hazily defined ?

Precisely defined.

57 On your diagram you have sketched a dark area to the right of the centre of the object. Was this darker area sharply defined or hazily defined ? Did this dark area remain consistent or did it shift ? How can you be sure that this was not an optical illusion due to the brightness of the main part of the object ?

The dark area was hazily defined at its boundary with the yellow zones. The dark zone was glittering/shaky – Ray found this aspect difficult to describe. Ray did not think this was caused by an optical illusion e.g. because of the brilliance of the adjacent yellow light.

58 You were quoted in The Guernsey Press saying that this first light was "about 10 miles away" and then you said that "I later realised it was approximately 40 miles from us". You compared the light with a 737. On what did you base these estimates of distance and size ?

The sharply defined structure.

59 Did you notice any unusual effects in your cockpit – for example to your instruments or radio communications - during this initial stage of your sighting ?

None at all. Ray himself checks the instruments before and after all flights. No problems whilst in flight.

60 At what point did you contact Jersey ATC ?

After 2-3 minutes.

61 What did you say to them ?

"Do you have any traffic on a reciprocal heading ?"

62 How did they respond ?

"No."

63 Did they have any unusual targets on their radar system ?

At first no. Ray asked again 2 minutes later and they still had nothing on their radar. It was only on the third [possibly fourth, PF] occasion that Ray was asked to describe what he was seeing and then Jersey ATC reported a primary contact. Ray reported the lights on a secure frequency.

64 Have you subsequently spoken to these people about your sighting and their target ?

Not about this sighting. Ray has spoken to Paul Kelly to find out where the radar tapes are stored but not spoken to him about the radar tracks. Ray knew Paul Kelly two years previously [I think just in passing, PF] [Ray has ticked this]

65 Does Jersey ATC often have unusual returns on its radar during your flights ?

Ray has not heard of Jersey ATC having unusual targets before but he may not be privy to these. Ray said that Jersey ATC have jurisdiction up to 18,000 feet, it is French airspace above that height.

66 Do you know at what range and height the Jersey ATC radar can see when pointing towards your aircraft ?

[Omitted as we can get this from Paul Kelly]

67 Did you see any ships below you when you were observing the first light ?

Cannot recall seeing any but it was very hazy below the aircraft.

68 How did the first light disappear ? Was this due to atmospheric conditions or was this due to the light's behaviour, or a combination of both ?

Ray believes that the lights disappeared from view almost as soon as he descended into the hazy level at about 2,000 feet. Above the haze he could see 100 miles in all directions but once in the haze visibility dropped to 5-7 miles. These figures are a bit misleading because Ray could see straight ahead for some miles but looking down through the haze at an angle visibility was much reduced. The haze was a general atmospheric haze due to bad air from the continent, it was not a salt haze from the sea. Ray could not see the horizon when he landed on Alderney.

69 Did the 1st light flicker or appear to move as it disappeared ?

No. The first light was stationary. It did not flash.

70 What height were you at when the first light disappeared ?

About 2,000 feet. [Ray has indicated that this question assumes both lights disappeared at different times - in fact they disappeared at the same time.]

71 Were you still on the same course as prior to the sighting and at the same speed; or had you made any course adjustments during your observation of the first light?

Yes. However, Ray made a few very minor course adjustments as he came into land.

72 Where were you on diagram 1 when the first light disappeared ?

[We need to compute this from the timing on the ATC tapes, PF]

73 Did you see the second light when the first light was still visible ? If not, how long after the first light disappeared did the second light appear. Please mark Diagram 1 to show where you were when light 2 appeared.

Yes, Ray could see both lights. They both disappeared at the same time. He was at point B, ORTAC, when the second light appeared. ORTAC is an imaginary point at 50 N in the airway and borrows its name from the actual Ortac rock west of Alderney by about 2 nautical miles.

74 When the second light appeared could you see the Islands of Alderney and Guernsey, and if so – how distinct were they ?

Yes, they were both pretty clear.

75 Where was the second light in the sky ? Was it above/below/same level, to the left/right/straight ahead ?

Initially the second light was slightly to the right of the first light – perhaps by 10 degrees. As Ray descended into haze the two lights appeared to be lined up. See DIAGRAM 4.

76 Was this second light as bright as the first light ?

The second light was slightly dimmer than the first light.

77 Did the second light appear to be the same size as the first light ?

The second light was about half [slightly more than half, PF] of the size of the first light. However, Ray thought that this was just because the second light was [much] further away. See Diagram 4.

78 For how long did you observe the second light ?

6-7 minutes. Ray immediately reported the second light to Jersey ATC on his frequency. 118.85 MHz Ray thinks.

79 Did you observe it through binoculars ?

Yes

80 For how long did you observe this second light through binoculars ?

6-7 minutes.

81 How certain can you be that this is an accurate estimate ?

We need to refer to the ATC tapes.

82 Did it appear to brighten or fade ?

No.

83 Did it flash on and off – and if so, at what periodicity ?

No.

84 How sharply defined was this second light ?

As good as the first light.

85 Was your impression that you were observing a bright reflected light or something that was emitting light ?

Emitting light.

86 How long was it before you observed the second light through binoculars ?

Almost immediately. At one point Ray could see both lights at the same time through his binoculars.

87 For how long did you observe the second light through binoculars ?

[Duplicate question, PF]

88 Was this second object sharply or hazily defined when seen through binoculars ?

Sharply defined.

89 Did this impression change when you observed the second light through binoculars ?

No.

90 Please can you draw the second light as you first saw it, then as you saw it through binoculars. Please show any features or colours. This is Diagram 3.

The second light was exactly the same as the first light.

91 Did you notice any unusual effects in your cockpit – for example to your instruments or radio communications - during this second stage of your sighting ?

No.

92 Did your onboard radar indicate any target that might have correlated with the second light ?

N/A.

93 How did the second light disappear ?

Same as the first one, when Ray descended into the hazy area.

94 Did the 2nd light flicker or appear to move as it disappeared ?

No.

95 Do you attribute the disappearance of both lights wholly to haze or did the lights' behaviour contribute to their disappearance ?

Purely due to the presence of the haze.

96 Were you still above the sea when the 2nd light disappeared ?

Yes.

97 Could you see the islands of Alderney and Guernsey distinctly at the end of the sighting ?

Alderney could be seen distinctly, Guernsey was in haze.

98 Were you still on the same course as prior to the sighting, and at the same speed; or had you made any course adjustments during your observation of the first light?

Yes. Ray made some very slight course corrections as he came into land to line up with the runway. [!]

99 Did you see any ships below you when you saw this second light ?

Can't recall seeing any.

100 About how long did the whole encounter last ?

10-12 minutes.

101 How certain can you be that this is an accurate estimate ?

The ATC tapes will give an accurate figure.

102 Did you report the lights' appearance to your passengers ?

No, not until he landed. However, as reported in question 15 at least 3 people noticed the lights themselves.

103 Did you have a record of their names and addresses so that we can contact them ?

N/A

104 Did you see any other unusual phenomena during the encounter ?

None.

105 Are you aware of anyone living on the Channel Islands seeing or reporting unusual lights at the time of your encounter ?

No. However, some pilots have reported seeing lights to Ray.

106 What was the first thing you thought of when you saw the lights ?

Ray thought they were the reflection off the Vinery/Greenhouse.

107 Did you think in terms of substantial "objects" or perhaps some insubstantial weather or optical phenomenon ?

Ray thought he was seeing substantial objects not weather/optical phenomena.

108 How do you feel about Jersey ATC characterising the radar contact as a possible anomalous propagation effect ?

Jersey ATC reported anomalous propagation to Ray's left hand side [east/south east] in cloud as he began his descent. Two minutes into the sighting Jersey reported a primary target and this was overflown by BAE146 Gatwick to Guernsey. However, the pilot of this aircraft saw nothing. Captain and Flight Officer on this flight have confirmed this.

109 Did Jersey ATC describe to you in any detail what they could see on their screen ?

No, they just reported seeing a primary contact.

110 What does the CAA have to say about the radar contact ?

Nothing. They have not spoken to Ray. Neither has the UK Ministry of Defence spoken to Ray.

111 Did they talk directly to you about the radar aspect ?

No

.

112 Did they alter their story once they had spoken to Jersey ATC ?

No.

113 How has your airline treated you for going public with this sighting ?

There have been no problems. The sighting was leaked to the Guernsey Press by a third party [someone at the airline?] and the newspaper contacted Aurigny. The Managing Director Malcolm Hart contacted Ray to ask him if he minded talking to the press so Ray gave an interview. Ray felt that the airline welcomed the publicity.

114 Have you ever seen anything else which you could not identify during a flight ?

Yes, Ray has already reported to David Clarke that on a previous occasion he was flying from Alderney to Southampton when a large cylindrical object 25-30 degrees in arc appeared before him for 2-3 minutes. The object was thin and 4 times in height to its width [?]. It was lost in cloud. Ray also recalls the light that was seen by a Police helicopter over Brighton which appeared on the front page of the Brighton Argus a few years ago. [I'm not sure from my notes whether Ray actually saw this light, PF]

115 Have you spoken to the pilot of the Blue Islands aircraft about his sighting ?

No

116 Do you know his name ?

Yes but at present it is private so he cannot release the pilot's name to us.

117 How certain do you feel that he saw the same light as your first light ?

It was similar so could be the first light Ray saw. It was briefly seen by this other pilot at his 8 o'clock position, which is behind his left shoulder [to the north of his aircraft, PF]. He was travelling at 4 miles a minute [nearly twice as fast as Ray's aircraft] and had no onboard radar.

118 Have any other pilots known to your reported seeing similar lights or objects in the Channel Islands area recently ?

No, not similar. Several have reported seeing unusual objects to Ray.

119 The Guernsey Press reported that you were flying from Southampton to Alderney but the BBC web site states that you were "about to fly an Aurigny plane from Alderney to Southampton". Surely the BBC account is wrong ?

The BBC account is wrong.

120 The CAA aeronautical chart shows several areas to the east of the Channel Islands which are French controlled flying zones. Please could you explain what each of these zones means.

[See additional notes below, PF]

121 Are you aware of any recent balloon flights from the Cherbourg peninsular or Normandy or Brittany which might fly over the Channel Islands if the wind is in the right direction ?

No. Ray has never seen balloons in the Channel Islands area. Any balloons seen over the Channel Islands would have to be launched from Brest [or as I suggested the mid Atlantic, PF] due to the prevailing south-westerly wind.

122 Did you report your sighting to the French Authorities once the British Ministry of Defence stated that the sighting took place in their air space ?

No.

123 Have the French authorities contacted you about your sighting ?

No.

124 Have you had any follow up interviews or conversations with the Ministry of Defence of the Civil Aviation Authority since submitting your report ?

None.

End of interview. Interview began at circa 17.05 and ended at 19.05 Hrs BST.

Towards the end of the interview Ray drew Diagram 5 which attempts to show how his angle of sight to the lights changed from a few degrees to the right to about 20 degrees to the right as he neared Alderney.

* * *

The following list of questions had been compiled by Martin Shough and was put to Capt Bowyer by Paul Fuller at the same interview

1) Times of first and last sightings.

In CAA SRG report.

2) Location, heading and altitude of aircraft at time of first sighting.

In CAA SRG report.

3) Location, heading and altitude of aircraft at time of last sighting.

The aircraft’s heading changed by between 3 and 5 degrees between the first and last sightings.

4) What first drew your attention to the 1st object?

Ray’s attention was drawn to the first object by its brilliant light.

5) Could you estimate the angular widths of each object, in terms of familiar objects at arm's length or measurement at arm's length?

See answer to question 46.

6) If the 2nd object was initially not seen, why do you think this was?

The 2nd object was probably just below/on[?] the top of the haze layer. It is possible that the SW breeze pushed the haze up higher in the lee of Guernsey (i.e. towards Alderney and Ray’s aircraft).

7) Were both objects in view simultaneously for a time?

Yes, both objects were seen at the same time for a time.

8) Were both objects the same in every respect (shape, colour, brightness, sharpness etc) except for apparent size?

Yes, see answer to questions 76, 77 and 90. Second object slightly dimmer. Otherwise both were identical.

9) Did they change in appearance (size, position, shape, colour, brightness, sharpness etc) during the sighting?

Objects changed slightly – became larger, shifted towards right, but retained their internal consistency.

10) Can you describe the appearance of the "dark bands" on the objects in more detail - i.e., the shape, sharpness, and colouration (if any) and what "dark" means a) relative to the object(s) and b) relative to the sky/sea background?

The dark areas were darker than the yellow part of the object and lighter than the background (haze/ground). The dark was a "graphite grey" colour. The dark bands oscillated on both objects.

11) At what point during the sighting did you begin using binoculars?

1.5-2 minutes. See answer to question 50.

12) Were any of the details described visible only through binoculars - i.e., if you had not had binoculars with you, would your description of the objects have been exactly the same?

No, both objects appeared the same when seen visually as they did when seen through binoculars. The only difference was their size and brilliance.

13) Did you and the passenger witnesses compare observations at the time?

No, Ray did not compare his observations with those of his passengers. See answer to question 15.

14) Did they express an opinion about what they were seeing?

"Never seen anything like this before" and "Very unusual".

15) Did you point out the presence of the object to them or did they spot it independently?

The passengers who saw the lights spotted them independently of Ray, he did not point the lights out to them.

16) In your opinion, were the objects reflecting sunlight or self-luminous?

The objects were self-luminous, not reflecting sunlight.

17) Can you describe the way in which the objects were lost to view ?

See answer to questions 68 and 93.

18) The presence of haze has been mentioned. Can you describe the altitude(s) and density of the haze?

Ditto.

19) What was the visibility of the islands like from the air as you approached Alderney?

See answer to questions 74 and 97.

20) Were the objects seen against the sky or the sea as a background? Was the sea horizon distinct?

The objects were seen against both the sea and the Islands.

21) You mentioned that your first thought was of sun reflecting from Guernsey greenhouses. Was this an effect you had seen before?

Yes, see answer to Question 44.

22) Could you see the island of Guernsey itself at this time?

Yes, Ray could see Guernsey when he saw the first light.

23) If so, would you be able to compare the apparent width(s) of the objects(s) to the apparent width of the island (i.e., similar, half as wide, twice as wide etc)?

See answer to question 46.

24) Can you give the apparent visual position(s) of the object(s) with respect to Guernsey (i.e., "same bearing", "one island width to the left", "five degrees to the right" etc)
a) when first seen b) when last seen?

When first seen the objects were at an oblique angle to the right of the flight path straight to Guernsey. See diagram 3.

25) Could you estimate the approximate *true* position(s) of the object(s) with respect to any of the islands?

no answer recorded

26) Did you circle around to the S of Alderney in order to land into the wind on the E-W tarmac runway?

No, Ray did not circle the island to the south, he landed on runway 26 coming straight in from the NE. [Ray has ticked this question]

27) Do you recall looking again for the objects as you approached, or from the ground after landing?

Ray looked for the objects as he approached Alderney but by then they had disappeared. Alderney ATC could see nothing either.

28) What was the visibility like on the ground compared to the visibility in the air?

[No answer recorded]

29) Do you think that one or both of the objects might have been visible from the ground had they still been there?

Ray thinks that had it not been for the haze both objects would have been visible from the ground. [Ray has ticked this question]

30) How would you characterise the flying conditions generally? Was there anything else unusual about the day?

Flying conditions were “standard”, it was a “normal day”.

31) How long had you been flying this route? Would you say you were very familiar with the appearance of the area in different conditions?

Ray has flown this route for 8.5 years and is very familiar with the area under different flying conditions.

32) I understand that you know the names of two passengers (the Russells) who were also witnesses. Are you able/intending to contact them for their accounts of the object?

Ray has not spoken to the Russells since they left his aircraft, but he believes that John Russell gave an interview on Radio Guernsey. Of course there may be a tape recording of this interview.

33) How many of your total (16 or 17?) passengers did, to your knowledge, see the objects?

Ray thinks that 5 of his passengers saw the lights.

34) To your knowledge, did anyone take any film or photos?

As far as he knows no one took photographs of these lights. [Ray joked with me that he had taken photographs !]

35) Did you notice any unusual responses from cockpit instruments at any time?

Ray noticed no unusual responses from the cockpit instruments at any time during the flight or sighting.

36) Have you ever seen/reported anything like this before?

Ray has seen another object (see answer to question 114) which he has described to David Clarke but he has never reported seeing an object until this sighting.

Additional notes by Paul Fuller

Martin, in answer to your first point, both lights became larger as Ray flew towards them. The first light grew to 15-18 mm in size using the ruler at arms length test, the second light grew to 6-8 mm at arms length. These are the largest estimates of angular size that we have.

I have loaned Ray my camera to take photographs of the aircraft and the horizon/islands and cockpit windows as he approaches Alderney. There are 24 exposures for him to use up ! Unfortunately I cannot fly so cannot take these photographs myself. [The photos show DME distances from Guernsey. First sighting 50-ish nautical miles from Guernsey. Last about 30 nautical miles.]

I did not raise the radar questions as he already has these by email.

Jean-Francois Baure's Questions
Hi Jean-Francois,

I hope the above response at Question 46 answers your question about the angular size but if not we can always go back to Ray. Ray does not recall saying that the lights were "25 miles" away. He has indicated on Diagram 1 that when he first saw the first light he was still north of ORTAC and that he thought the first light was 15 nautical miles away. He was at Flight Level 40 (circa 4,300 feet). He did not see the second light until he reached ORTAC (at 50 degrees latitude). He thought the second light was 50 Nautical miles away. The Casquets Lighthouse was seen to the right of both lights. None of the diagrams are to scale. SAM = Southampton Airport, IOW = Isle of Wight, ALI = Alderney.

Diagram 3 shows the same situation, The first light was thought to be approximately 2 nautical miles south of the Casquets Lighthouse as seen from "1st sighting" whilst the second light is 10 nautical miles south west of the Island of Guernsey [Note by MS: Ref. Diagram 3, this should read "10 nautical miles south west of the first light"], slightly to the right of the initial line of sight from the first light.

Both lights were seen against the both the ground and haze. The lights were both seen on or just below the horizon, then above as Ray descended.

The cloud/haze distribution is answered in question 27, 68 and 95.

None of the diagrams are to scale, they are just representative.

The shaded area around Sark on the CAA Aeronatical Chart sheet 217100 edition 25 is a noise-restricted zone. Aircraft are not permitted to fly below 2,000 feet to prevent noise pollution. Aircraft have no other restrictions in the Channel Islands area except that they have to ask permission from the relevant ATC to enter the areas surrounded by the dashed lines. The shaded areas on the Cherbourg Peninsular are within French Airspace and are restricted zones but aircraft flying from Southampton to the Channel Islands should not be anywhere near these zones anyway. There is a large airport at Cherbourg. Two nuclear plants on the French coast - one exclusion zone.

Paul Fuller, 9th June 2008

* * *

ii) Follow-up questions answered by Capt Bowyer, 17.08.07

Questions submitted by Martin Shough and answered by email:

1) With reference to your flight track, could you indicate the positions/times:
a) of the plane at the time when you last saw the objects disappear in haze

> I lost sight when the aircraft descended through 2000 ft. You should be able to determine this from the radar plot.

b) of the plane when you noted that the bearing to the object(s) had rotated westward to 20 deg

> Probably at about the same time.

2) Can you describe again the relative angular positions of the two objects at the time when you last saw them? If ------ and --- represent the large and small objects, which of the following (if any) is most nearly correct?

a) ---------
----

b) ----
----

c) ---------
----

d) ---------

> At last sight the closest object was in my one o'clock the second at about 12 o'clock and appeared smaller and to the left of the closer object due to the relative perspective. Remember that the aircraft position is not a constant. Relative headings are changing constantly as can be seen by the plot. I would say position c.) except reversed. The smaller object finally appeared higher and to the left of the closer and therefore larger object. i.e. --- _ _ _ _ whereas at first sight they were _-_-_-_ .

3) At the time when you last saw them, how far above the bottom one was the top one, in terms of a fraction or multiple of its own length?

> As a multiple of its own length of the farthest object I would say perhaps 6 to 8 times. Very difficult to say due to the offset angle between both objects.

4) When first seen, was the first object visible against the sky or against the sea?

> Visible against the sea.

5) At what position/time during descent would you estimate that you could no longer distinguish the horizon?

> The horizon was visible at all times. The haze layer itself forms a horizon as it disappears off to the horizon! The sea and the haze layer merge at the horizon. At 2000 ft items or objects at or on the top of the haze layer are shrouded by the dirt in the air.

6) When both objects were in view together towards the end of the sighting, was one of them, or both of them, or neither of them, visible at any time above the horizon, and if so by what angular distance (in terms of some fraction or multiple of its own length)?

> At the time of last sighting both objects were visible on the horizon i.e. the haze horizon which coincides with the actual horizon. Both objects disappeared from my view simultaneously at 2000 ft.

7) At what position/time after the second object appeared were both objects visible simultaneously in the same binocular field of view?

> Immediately. Only due to the relative position of my aircraft did the second object appear to 'move' left. Can't remember now exactly when the second object appeared but probably 5 miles NNE of ORTAC on the 207 radial from Southampton. At the time I made a comment to Jersey ATC so this should be recorded on the audio tape.

8) Can you remember at which position/time you disengaged the autopilot? (At about 1412:30, just after passing ORTAC, the radar plot of the Trislander appears to show a gradual turn from 207deg onto a course of about 212deg, towards the objects, followed at around 1418 by a correction back on to ~190deg for the approach to Alderney.)

> The autopilot was engaged throughout the flight until a very short final, sat 1 mile from Alderney airport. Work load was high. I don't remember turning towards the objects specifically but this is probably due to the central wind screen divider being quite large on a Trislander and may have obscured the view of the closest of the objects.

9) Did you notice any afterimages when looking away from the objects after viewing with binoculars or naked eye?

> No after-images were visible after removal of the binoculars.

* * *

iii) Statement by Kate Russell, 28 June 2007:

The Trislander is a little plane, it holds about 16 people maximum. There's no separation between the passengers and the pilot. It's a bit like sitting in a car, there's no aisle like in larger aircraft.

We were sitting four rows back behind Ray, the pilot. There was a couple in front of us, and a man on his own sitting directly behind the pilot.

During the flight, as we were on the run to the airport, I was reading a book. I noticed Ray was turning around and talking to the man behind him. I have never seen this happen before, it was very unusual. Other passengers then started paying attention. This went on for some time, but at this point because of the position of the plane I could not see what they were looking at.

Ray then dropped the nose of the plane down. I could then see something through the windscreen.

It looked like the sun reflecting off glass. What I was looking at was a very bright light over the sea below us. It could have been sunlight reflecting off something. There were two lights. The second was roughly where I was expecting the airport to be (over Alderney). The lights persisted for a few minutes.

Then the plane lifted up again and I lost sight of them.

Then when the nose dropped again I saw the light again; at first I thought it was a light reflecting from a ship on the sea. My husband said it was an orange colour, but he's colour blind! What I saw was definitely not an orange light. I saw a bright white light; it was a 'sunlight-coloured light' if you understand what I mean? The second time I saw it had more of a [yellow] tinge? So I saw them on two separate occasions.

I saw two lights; one was larger – it appeared to be closer than the other – and whilst I was watching the second time I could clearly see a little fishing boat on the sea below (could they have seen it too?).

When we landed Ray asked 'did anyone see that?' and asked us to leave our names. He did not tell us what he had seen. I left my name but the man sitting behind him did not leave his; he wasn't from the island and I didn't recognise him; he didn't want to get involved and I got the impression he didn't want anyone to know he was there!

I then began to look for explanations but could not find them.

The first time I saw it, it was definitely below us. I was looking through Ray's windscreen. It appeared to be on the water, and the second appeared to be over the land (Alderney). The one that seemed closer, appeared to be about 10-15 miles away, but it's impossible to be sure.

However, there is one thing I disagree with Ray about. He says it must have been huge, but I didn't think it was anything like as large as he saw. But it's difficult to estimate size. [the first one] appeared to be at the halfway point between us and Alderney. It was shaped like a fat cigar – held at arm's length. But we just saw a light, there was no solid outline to it.

Ray is a sound rational man but he was quite shaken by this.

I don't believe in little green men and I don't think this was a UFO. I think it was something quite extraordinary, but something for which we don't have an explanation at the present moment. I suspect it was something natural but unexplainable.

Since the sighting we have had a couple of calls from the media but no one else before you wrote to us.

However there was an article in our local magazine, the Alderney Journal, a week ago from a chap who believes the lights were a sundog, caused by the sun's rays reflecting through ice crystals. Ray wrote a letter, which was published this week, saying this was not what he saw. He said on the day of the sighting visibility was good, with a haze below 2000 ft. At 8000 ft there was a layer of stratus clouds covering the whole of the English Channel and blocking out the sun. He says he has seen sundogs before, and these two objects were both to the same side of the sun in their relative positions which is not what you would see if it was caused by parhelia.

(Transcript of shorthand notes from telephone interview by Dave Clarke)

* * *

iv) Statement by John Russell, 28 June 2007:

We were sitting behind the pilot, 4th row back in the seats. At some stage my wife drew my attention to something outside, through the windscreen. Because of where I was sitting, I had to physically lean over her to see what all the fuss was about. There was only one object that I saw, but Kate saw two.

It was a lozenge-shaped, orange light. It was a brilliant object. It was a lot brighter than the reflection of the sun would create. However, the sun was in the right position to have been bouncing its rays off something.

A local scientist here thinks it is a sundog, he's written about it in the Alderney Journal. Ray has written a letter in to contradict this theory, saying the aircraft was at the wrong altitude.

It was a hazy day and we were descending from 4000 ft. The pilot got agitated and called to the man sitting behind him. This bloke was by himself. We don't know him, he's not from the island. But he was talking to the pilot for some time before we saw it, and he got the chance to look at it through the binoculars.

I got the impression the light I saw was moving, possibly in a westerly direction.

It's size? I thought it was much smaller than Ray has been quoted as saying. It was significantly smaller than any of the merchant ships we had passed over earlier in the flight before we started the approach.

(Transcript of shorthand notes from telephone interview by Dave Clarke)

* * *

v) Notes of telephone interview with Kate Russell

by Jean-Francois Baure 22.07.07 (minor grammatical edits, M.Shough, 16.01.08)

The UAPs were observed below the horizon, when Ray dropped the nose of the plane down.

Kate initially thought the most distant UAP was coming from Alderney Airport, but she later located the two UAPs between the two islands of Alderney (visible) and Guernsey (not visible).

It looked as if the largest UAP came out from the water (seen against the sea). Kate saw the UAPs twice, during a few minutes, and between the two sightings the one above water seemed to have moved (though they were both seen stationary).

The UAPs were steady lights, no brightness fluctuations.

The weather and the visibility were not very good, Kate did not pay attention to the sun's direct visibility.

About the lighting uniformity: no crepuscular rays or godrays are reported, nor sun glints/sun glitters on the sea, nor strong contrasts between surface areas directly illuminated by the sun versus darker areas in the shadows of the stratus layer above. Kate acknowledges it is difficult in this case to discriminate between a phenomenon emitting its own light or just reflecting another light source, but those bright UAPs were not reflecting on the sea surface or illuminating their close environment. On the contrary, the background of the UAPs appeared darker, maybe due to the visual contrast with the brightness of the UAPs.

A small ship, probably a fishing boat, was just discernible and possibly close to the largest UAP. But it was hard to tell if it could have seen the UAPs. The UAPs' angular size appeared larger than any light reflections that could have originated from a ship.

At landing, Kate didn't have the feeling of having witnessed something strongly unusual until Ray asked some passengers if they had seen what he had himself observed. Kate is inclined to think she observed phenomena of natural origin that we may understand later.

Kate clearly stated several times that the UAPs were seen below the horizon during the two sightings (being seated in the 4th rank, when Ray pushed the nose of the Trislander downward). The main one looked as though it was coming from the water (Kate did not give a clear answer for the relative elevation of the two UAPs, Ray's diagram being more explicit for this point). The light phenomena were perceived as anomalous for their persistence and their size (lights bigger than those that could possibly have originated from a reflection on a ship's surface) but to Kate it was nothing extraordinary until the landing and Ray's questions related to what he saw.

* * *

vi) Notes of interview with Capt Patrick Patterson, Blue Islands Airways, 14 December 2007, by Dave Clarke

PP: I remember the incident quite clearly. It was hazy. What I saw was not "a mile wide" or anything. I saw something of a yellow colour like a Trislander - their [Aurigny] aircraft are yellow coloured. But Air Traffic Control say there was nothing to the west of Alderney because all aircraft were using the [R41?] airway which means they were to the east of the island. It appeared to me to be to the west or northwest of the island, which would have been on the wrong side. What I saw was in haze and was essentially just a colour in the haze. I couldn't honestly say it was an object, it was not very sharp, just something beige yellowish in that area. It wasn't self luminous. It was visible by light reflecting off an object, but hazy, not like a bright reflection from glass.

DC: Have you ever seen something like this before?

PP: No, I haven't. The thing is we didn't notice it until we'd gone past when we were asked to look. We were descending. It was hazy, but not big layers of cloud. If there'd been an object a mile wide as we were coming down we probably would have noticed it as we passed. But we didn't notice anything until our attention was drawn to it because it was sort of in our eight o'clock position behind us and I had to put my face right against the window to see it.

I know Ray [Bowyer] fairly well and he's not the sort who sees things, he's a straightforward sort of bloke. But I didn't see anything a mile across [referring to an interview with Capt Bowyer on TV's 'Richard & Judy' show] - that would have made my eyes open wider! Well, there could have been a large vessel on the sea in that position, but he's a fairly experienced pilot and I don't believe he would he would have said it was airborne if it was really at sea level. On the other hand, haze smudges the outlines of objects and might make them appear a little larger.

I couldn't see the horizon clearly from our position, just a couple of miles ahead and obliquely down. I know I could make out Alderney, but only just. And the object, because it was hazy, seemed to me to be roughly west abeam, possibly slightly north of that position. But things were very hazy, it was very difficult to see the horizon.

DC: Ray mentions seeing two objects, doesn't he?

PP: Yes. I don't know if the angle of the sun could have been right for some kind of refraction effect? What I saw did not have a sharply-defined outline, it was really just a spot of yellow or beige colour. I wouldn’t mind saying, yes, I saw it had three edges etc, but I didn’t, it was just a smudge.

What else would I compare it with? Well, who knows what the British and French Navies do in that area? They may have been dragging some kind of balloon or airship. They are always doing things that they don't tell people about.

None of the passengers saw anything, neither did my co-pilot. Because I was sitting on the left side of the aircraft I was able to see behind. He said, 'Let's have a look!' but he wouldn't have been able to reach over far enough, and when I looked back I'd lost contact with it myself. It was visible for about a minute but I was distracted and had to attend to things in the cockpit. I don't know whether I lost sight of it due to distance or weather.

The size of the object was larger than a Trislander would have been in that position, judging by the size of Alderney. Probably four or five times the size if my judgment of distance and elevation is correct. In relation to the position of Alderney that could then mean an airship or a balloon. If a Trislander is something like 50ft long then we're talking about 150-200ft if my estimate of the angular comparison with the island is correct, although again, because haze blurs outlines you might think something is larger than it really is because it's diffuse. What I wrote in my report, straight away after landing, that's the closest I could get to saying it was something, a smudge of colour that was not at sea level and was not attached to the land.

There are all sorts of rocks to west of Alderney, covered in guano in places. Who knows, if you get the right reflection off that . . .? But I don't know why it would be yellow, because I have a recollection that it was a definite yellowish beige. Maybe the haze discoloured the reflected sunlight? You'd have to be in the right position, but perhaps Ray was in cruise without changing altitude and was able to see a reflection for a long time, whilst we were on the way down and maybe we soon moved out of the band where we were able to see it?

It didn't appear to move. Bearing in mind that we were receding and descending it seemed to remain in a constant position with respect to Alderney.

It was not bright. It didn't appear to be emitting it's own light. It was substantially dimmer than sunlight. Just something yellowy or beige in colour.

DC: How long have you worked for the Blue Islands company?

PP: I've been with the company for 3 years. I have nearly 3000 hours of flying experience in total, something like 2500 hours as pilot in command - I stopped counting some time ago! This is a familiar route. We've been working it for a year or so. We're flying in the Channel Islands all the time.

DC: Have you ever seen anything like this, or been asked to look for anything like this, before?

PP: No.

DC: Or spoken to other pilots who have?

PP: No, only Ray. And I've seen a lot of weird stuff in aviation, but nothing like that!

As to what it was, bear in mind that it didn't move or follow me about. My best guess if wasn't a Trislander or a drone or balloon being dragged behind a ship or a reflection off a rock or something, then - a weather phenomenon. I didn't have any strange feelings of fear or shivers down the spine or any reactions like that.

Paul Kelly, the Air Traffic Controller, called me up and said "Look. we've got the MoD crawling over this one. Can you write down what you saw?" So I did. They said the radar had something. But you know the difference between primary and secondary radar? With inversions it could be reflecting off a rock or a ship or something miles out in the ocean, and height is not known. I've had experience of these things before. ATC calls you up and says "We've got something here but we suspect it might be a reflection off a ship, and it turns out to be nothing to worry about. As I said to Paul, if you had the ability to travel across space and time why would you hang around Alderney?

I heard the French space agency were looking into this. They called up my company and made a request to speak to me, but it got turned down. It wasn't my decision, I knew nothing about it.

It wouldn't surprise me if the French, British or US have something years ahead of anything we know about and are testing it out to see if we can detect it.

(Transcript of shorthand notes from telephone interview by Dave Clarke)

* * *

vii) Capt Patterson's answers to written questions

1. Position of own a/c.

    5NM north-west of Sark

2. Speed of own a/c.

    Approx. 230 KTS indicated

3. Heading of own a/c.

    ~ 170 degrees

4. Altitude of own a/c, and whether in level flight/ascending/descending.

    Altitude 3,500' descending

5. Time of sighting.

    1415Z

6. Apparent relative altitude of sighted phenomenon.

    Estimated 2,000' below

7. Duration and nature of observation (ie, was it a couple of snatched glances over his shoulder, or something more substantial?).

    I looked several times, total duration about one minute

8. Any apparent motion of observed phenomenon.

No apparent motion

9. Description of phenomenon - regular/irregular form, variations in shading, colour, single or multiple phenomenon/a, alignment if multiple, impression of depth.

Possibly oblong/oval, yellow/beige colour, little definition due to haze, little depth

10. Knowledge of other witnesses other than those in Bowyer's company.

FO aware of ATC request but unable to view due to position in cockpit

11. Recollection of weather conditions.

Hazy but smooth, no significant weather.

12. Was the horizon clearly discernable despite any haze/cloud?

No

13. If so, what was the elevation of the phenomenon in relation to the horizon (i.e. how far above or below, in angular measure and/or in terms of some distance at arm's length)

[n/a]

14. Was the island of Alderney clearly visible in the haze?

Just visible in outline

15. Where was the object in relation to Alderney (i.e., angular measure or distance at arm's length)

~ 2NM west of Alderney by appearance

16. What was the apparent size of the object, i.e. length compared to Alderney and/or angular measure or width at arm's length?

~1/2 NM max

17. Was the object a) sharply-defined in outline, b) like a well-defined cloud, c) like a fuzzy cloud, d) just a hazy patch?

Hazy patch

18. To what other familiar object or phenomenon would he most nearly compare it?

[no answer]

19. To what familiar object or surface would you compare the "yellow- beige" colouration?

About the same as a yellow Aurigny Trislander would look in the same position and distance although object seemed larger

20. During the sighting did the object maintain the same position, or change position, in relation to a) the horizon and b)Alderney?

No change in position relative to either but ultimately lost from view

21. Could you see the island of Burhou at the time?

Yes

22. Do you have any suggestion as to why the object was not visible when he was passing Guernsey at about FL70 - 65 when first asked to look, saying you could see "nothing in that position at all, I can't see anything" at 1413:13, but was visible a couple of minutes later when down to about FL40?

No explanation

23. Would you describe the brightness and colouration of the object as due to reflected light or emitted light?

Reflected

24. Can you compare the colour, brightness and shape of the object with that of any other familiar object or effect seen that day or during a typical flight?

Only a yellow Aurigny Trislander seen through haze although size would of course not match

25. Do you have any opinion or ideas as to the most likely origin/source of the phenomenon you observed that day?

Atmospheric

* * *

Appendix C: Meteorological charts and tables

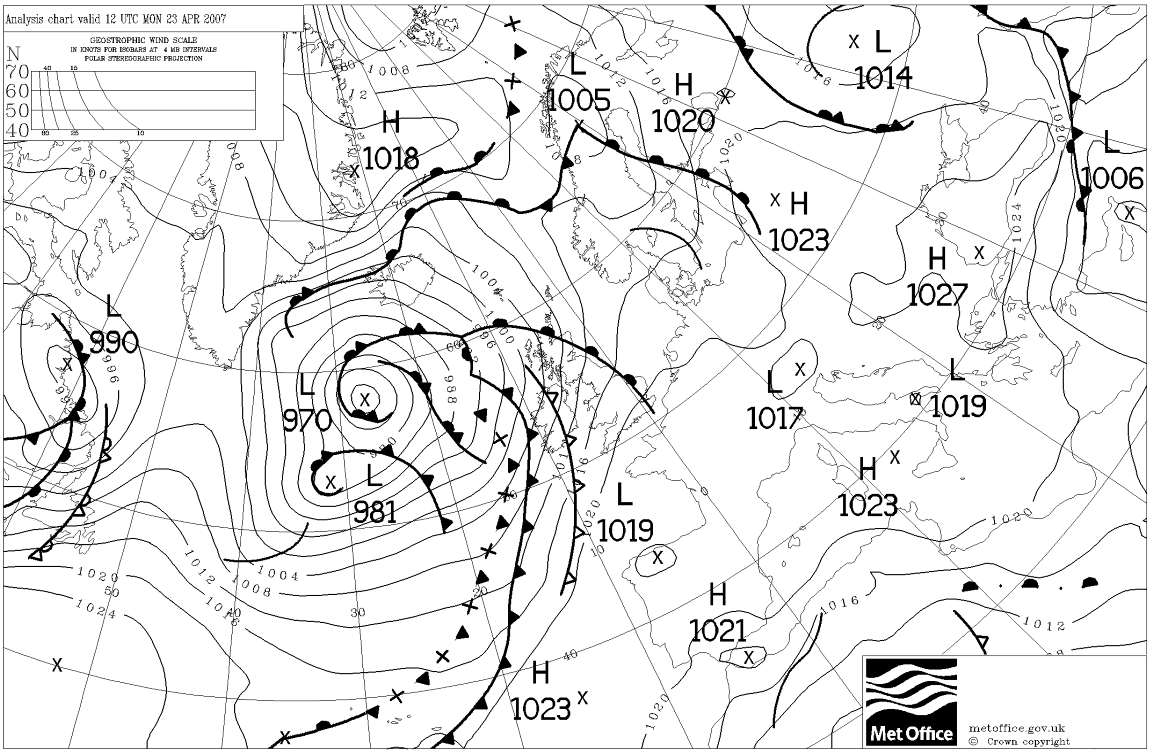


Fig.1 UK Met Office pressure chart, 1200Z 23 April 2007
(courtesy Tim Lillington, Senior Meteorological Officer, Guernsey Airport Met Office, and Met Office UK)

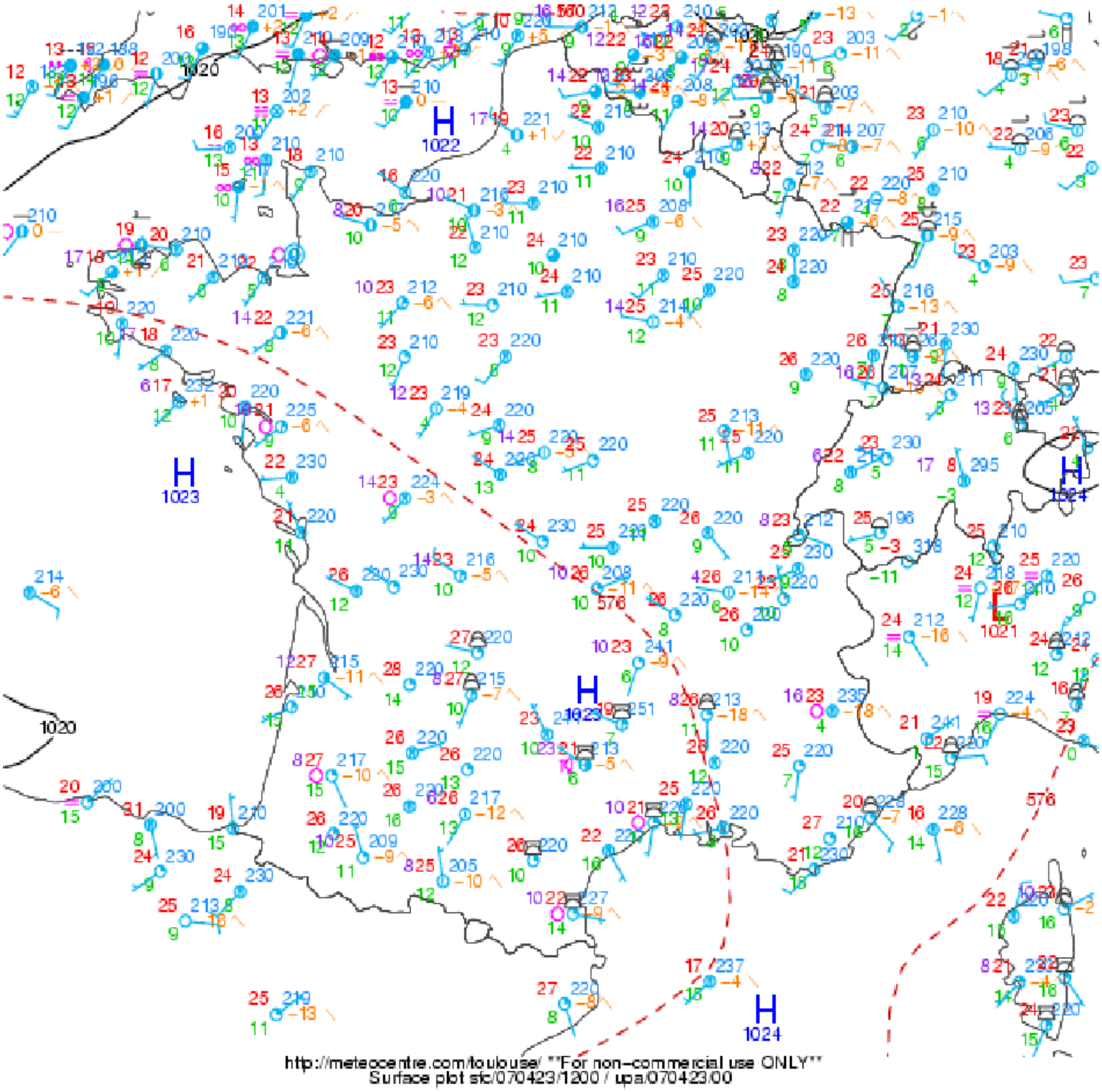
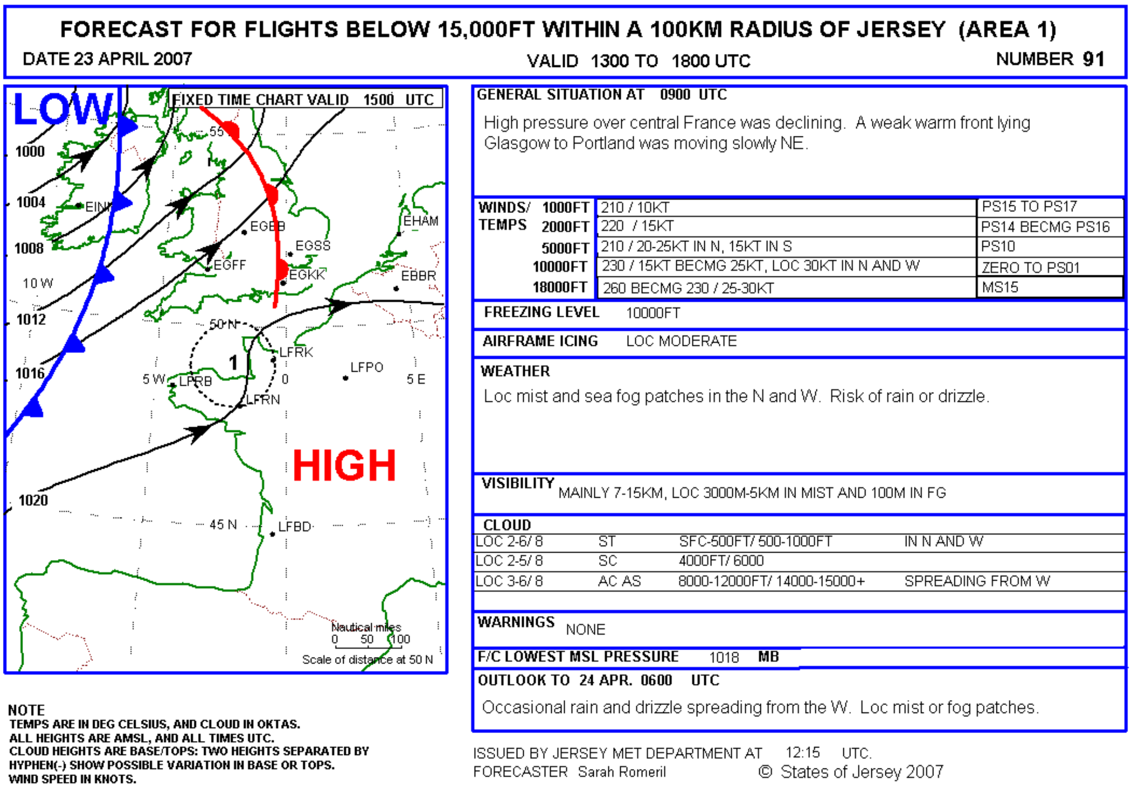


Fig.2 Surface winds and temperatures, France, 1220Z 23 April 2007
(courtesy Meteo-Centre, Toulouse)


FORECAST FOR FLIGHTS BELOW 15,000FT WITHIN A 100KM RADIUS OF JERSEY (AREA 1)

DATE 23 APRIL 2007 VALID 1300 TO 1800 UTC NUMBER 91

GENERAL SITUATION AT 0900 UTC

High pressure over central France was declining. A weak warm front lying Glasgow to Portland was moving slowly NE.

WINDS/ TEMPS		
1000FT	210 / 10KT	PS15 TO PS17
2000FT	220 / 15KT	PS14 BECMG PS16
5000FT	210 / 20-25KT IN N, 15KT IN S	PS10
10000FT	230 / 15KT BECMG 25KT, LOC 30KT IN N AND W	ZERO TO PS01
18000FT	260 BECMG 230 / 25-30KT	MS15

FREEZING LEVEL 10000FT

AIRFRAME ICING LOC MODERATE

WEATHER

Loc mist and sea fog patches in the N and W. Risk of rain or drizzle.

VISIBILITY MAINLY 7-15KM, LOC 3000M-5KM IN MIST AND 100M IN FG

CLOUD			
LOC 2-6/ 8	ST	SFC-500FT/ 500-1000FT	IN N AND W
LOC 2-5/ 8	SC	4000FT/ 6000	
LOC 3-6/ 8	AC AS	8000-12000FT/ 14000-15000+	SPREADING FROM W

WARNINGS NONE

F/C LOWEST MSL PRESSURE 1018 MB

OUTLOOK TO 24 APR. 0600 UTC

Occasional rain and drizzle spreading from the W. Loc mist or fog patches.

NOTE
TEMPS ARE IN DEG CELSIUS, AND CLOUD IN OKTAS.
ALL HEIGHTS ARE AMSL, AND ALL TIMES UTC.
CLOUD HEIGHTS ARE BASE/TOPS: TWO HEIGHTS SEPARATED BY HYPHEN(-) SHOW POSSIBLE VARIATION IN BASE OR TOPS.
WIND SPEED IN KNOTS.

ISSUED BY JERSEY MET DEPARTMENT AT 12:15 UTC.
FORECASTER Sarah Romeril

Fig.3. Jersey Met forecast for <15,000ft. 100km radius of Jersey, 1300-1800Z, 23 April 2007
(courtesy Tim Lillington, Senior Meteorological Officer, Guernsey Airport Met Office)

Altitude (ft)	Wind direction (true)	Wind speed (kts)	Temperature (C)
24000	260	20	-26
18000	250	20	-13
10000	230	25	+00
5000	230	25	+09
2000	230	20	+14
1000	220	20	+14

Table 1. Met Office Form 214 upper air forecast for 50°N 02°30'W, valid 0900-1500UTC, 23 April 2007
(courtesy Tim Lillington, Senior Meteorological Officer, Guernsey Airport Met Office).

Guernsey Airport weather reports Monday 23 April 2007
All times UTC
Cloud amounts in oktas

Time	Surface wind		Visibility	Significant	Medium level cloud			High level cloud			Temperature	
UTC	Dir°T	Spd (knots)	Surface (km's)	Weather	Type	Height (ft)	Amount	Type	Height (ft)	Amount	Air°C	Dew point°C
1150	180	6	5	Haze	Altocumulus	12,000	6				15	10
1220	180	7	6	Haze	Altocumulus	12,000	6				15	10
1250	180	7	10	Nil	Altocumulus	12,000	6	Cirrus	25,000	x	15	9
1320	190	7	10	Nil	Altocumulus	12,000	6	Cirrus	25,000	x	15	8
1350	190	6	10	Nil	Altocumulus	12,000	1	Cirrus	25,000	7	16	10
1420	230	7	12	Nil	Altocumulus	12,000	1	Cirrus	25,000	7	17	9
1450	190	6	12	Nil	Altocumulus	12,000	1	Cirrus	25,000	6	17	9
1520	210	6	12	Nil	Altocumulus	12,000	1	Cirrus	25,000	7	17	9
1550	210	8	12	Nil	Altocumulus	12,000	1	Cirrus	25,000	5	17	9

x = cloud observed but estimation of amount not possible

Alderney Airport weather reports Monday 23 April 2007
All times UTC
Cloud amounts in oktas

Time	Surface wind		Visibility	Significant	Medium level cloud			High level cloud			Temperature	
UTC	Dir°T	Spd (knots)	Surface (km's)	Weather	Type	Height (ft)	Amount	Type	Height (ft)	Amount	Air°C	Dew point°C
1150	180	9	5	Haze	Altocumulus	10,000	7				13	11
1220	190	7	12	Nil	Altocumulus	10,000	7				13	11
1250	210	5	12	Nil	Altocumulus	10,000	7				13	11
1320	190	5	12	Nil	Altocumulus	10,000	7				14	11
1350	200	6	12	Nil	Altocumulus	10,000	3	Cirrus	25,000	7	14	11
1420	190	6	12	Nil				Cirrus	25,000	7	14	10
1450	180	6	20	Nil				Cirrus	25,000	7	14	10
1520	180	5	20	Nil				Cirrus	25,000	3	14	9
1550	180	4	20	Nil				Cirrus	25,000	5	15	9

Table 2. Guernsey and Alderney Airport weather reports
1150-1550Z 23 April 2007
(courtesy Tim Lillington, Senior Meteorological Officer, Guernsey Airport Met Office)

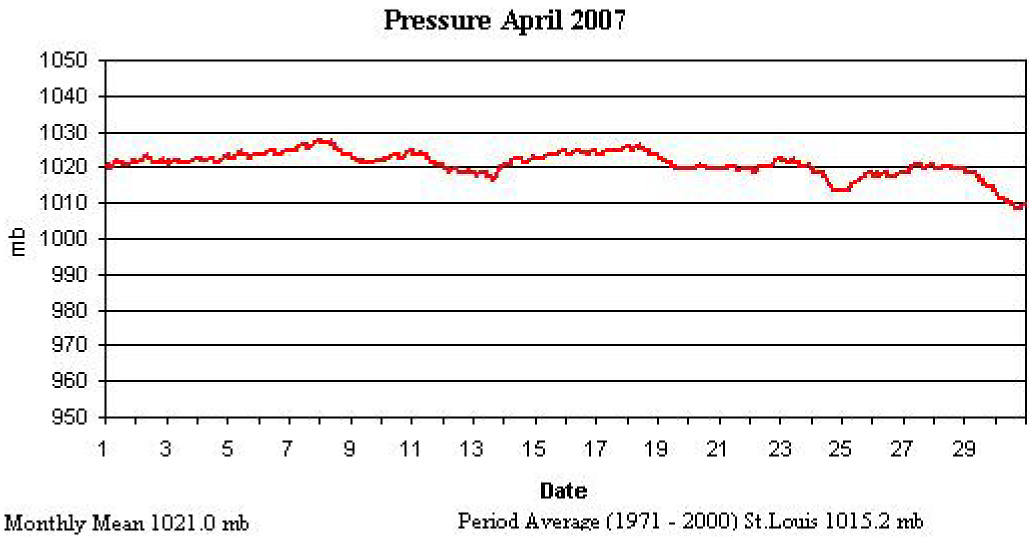


Fig.4 Jersey daily pressure record, April 2007
(Figs 4, 5, 6 & 7 from http://www.jerseymet.gov.je/)

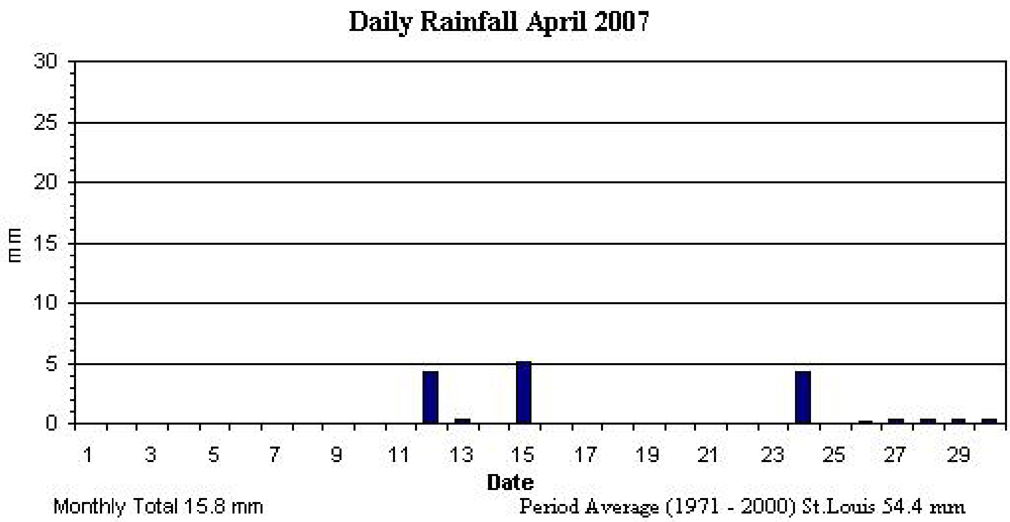


Fig.5. Jersey daily rainfall record, April 2007

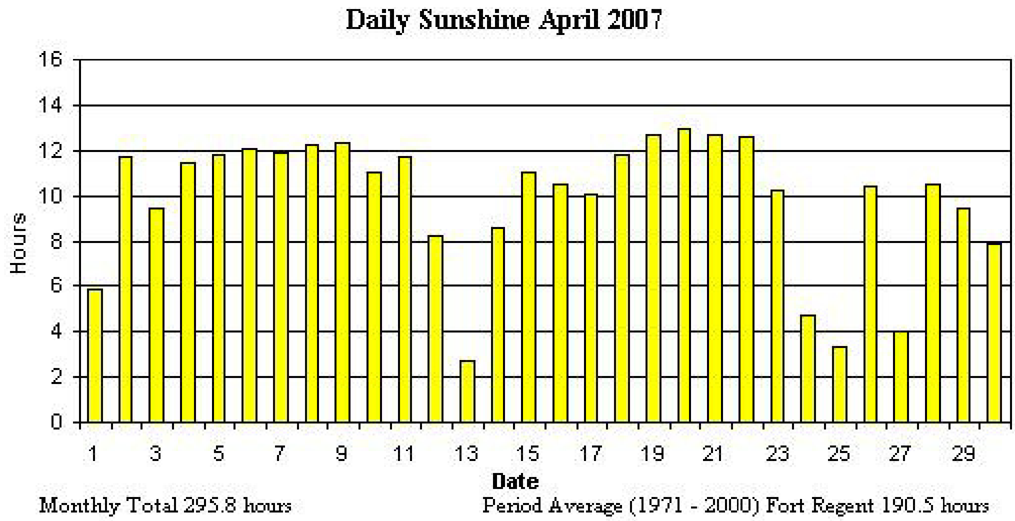


Fig. 6. Jersey daily sunshine record, April 2007

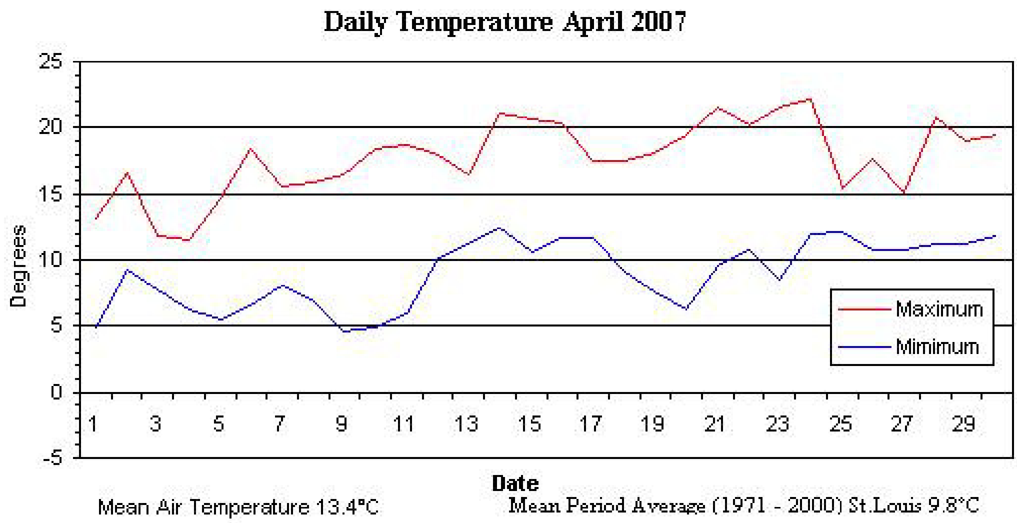


Fig. 7. Jersey daily temperature record, April

Channel Islands Shipping Forecast prepared for the area bounded by latitude 50°N, the French coasts between Cap de la Hague and Ile de Brehat, and longitude 3°W.

Issued by the Jersey Met Department at 12 noon Monday, 23 April 2007

General Situation

At 10am high 1024mb, over central France was slow moving. A weak warm front lying from the Lake District to Portland was moving slowly east, to be followed by a cold front tomorrow.

Forecast from 1pm on Monday until 1pm on Tuesday.

Wind:	S'ly or variable F1 to 3.
Weather:	Mainly cloudy with mist or haze. Risk of fog patches reforming overnight and some rain spreading in from the west at times.
Visibility:	Moderate, locally poor or very poor.
Sea State:	Smooth or slight.
Swell:	Not significant.

St. Helier Sea Temperature: 12 °C

Tides at St Helier:

Low	Water at	5.56 pm	3.6	Metres
High	Water at	11.39 pm	8.6	Metres

Forecast for the area from 50°N to the English Coast between Start Point and the Needles from 1pm on Monday until 1pm on Tuesday.

Issued by the Jersey Met Department at 12 noon Monday, 23 April 2007.

Wind:	S'ly or variable F2 to 4.
Weather:	Mainly cloudy with mist or fog patches, some rain spreading in from the west at times.
Visibility:	Moderate, locally poor or very poor.
Sea State:	Slight locally moderate.

At the time of issue the following warnings were in force:

Nil.

Table 3. Channel Islands Shipping Forecast, noon, 23 April 2007
(courtesy Tim Lillington, Senior Meteorological Officer, Guernsey Airport Met Office)

Table 4. Radiosonde profile for noon, 23.04.07, Brest, France
(all radiosonde data courtesy of U. of Wyoming College of Engineering weather server)

07110 LFRB Brest Observations at 12Z 23 Apr 2007

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1011.0	95	18.2	8.2	52	6.79	220	10	290.4	310.0	291.6
1000.0	188	16.8	6.8	52	6.23	220	11	289.9	307.9	291.0
968.0	463	12.8	2.8	51	4.86	224	13	288.6	302.7	289.5
935.0	754	12.6	-18.4	10	0.96	229	15	291.3	294.4	291.5
925.0	844	12.6	-5.4	28	2.78	230	16	292.2	300.6	292.7
920.0	889	12.6	-0.4	41	4.06	231	16	292.6	304.7	293.4
888.0	1187	12.4	-4.6	30	3.07	235	18	295.4	304.8	296.0
881.0	1253	12.0	2.0	50	5.04	236	19	295.7	310.7	296.6
850.0	1552	9.8	1.8	57	5.15	240	21	296.4	311.8	297.3
834.0	1709	8.8	1.6	61	5.19	245	22	296.9	312.4	297.8
814.0	1910	7.4	1.4	66	5.23	239	22	297.5	313.2	298.5
777.0	2292	6.2	-11.8	26	2.00	229	22	300.2	306.6	300.6
700.0	3138	0.6	-10.4	44	2.49	205	21	303.1	311.1	303.6
699.0	3149	0.5	-10.4	44	2.49	205	21	303.2	311.1	303.6
684.0	3323	-0.5	-10.5	47	2.52	207	21	303.9	312.0	304.4
669.0	3500	-1.7	-20.7	22	1.11	210	22	304.5	308.2	304.7
654.0	3680	-2.9	-10.9	54	2.56	212	22	305.1	313.3	305.6
620.0	4100	-5.7	-15.7	45	1.82	218	23	306.6	312.6	306.9
606.0	4279	-6.7	-17.7	41	1.58	220	23	307.4	312.7	307.7
580.0	4619	-8.2	-14.9	59	2.08	225	24	309.5	316.4	309.9
556.0	4947	-9.7	-12.2	82	2.71	214	23	311.6	320.5	312.1
547.0	5072	-10.3	-13.6	77	2.46	210	23	312.3	320.4	312.8
518.0	5490	-12.3	-18.3	61	1.76	231	24	314.8	320.8	315.1
500.0	5760	-13.5	-16.2	80	2.17	245	24	316.5	323.9	316.9
495.0	5837	-14.0	-15.9	85	2.24	245	24	316.8	324.4	317.2
494.0	5852	-14.1	-15.9	86	2.25	245	24	316.9	324.5	317.3
453.0	6507	-17.1	-39.5	12	0.28	230	10	321.0	322.1	321.1
448.0	6591	-17.5	-42.5	9	0.20	227	10	321.6	322.4	321.6
400.0	7430	-24.9	-49.9	8	0.10	195	13	322.5	322.9	322.6
388.0	7650	-26.8	-51.0	8	0.09	185	14	322.9	323.2	322.9
385.0	7706	-27.3	-51.3	8	0.09	188	15	322.9	323.3	322.9
350.0	8384	-33.5	-37.2	69	0.45	229	23	323.5	325.2	323.6
318.0	9051	-37.6	-40.9	71	0.34	270	31	326.8	328.1	326.9
317.0	9073	-37.7	-41.0	71	0.34	270	31	326.9	328.2	327.0
300.0	9450	-40.9				275	30	327.6		327.6
251.0	10634	-50.7				295	28	330.2		330.2
250.0	10660	-50.9				295	29	330.3		330.3
200.0	12070	-63.5				300	56	332.1		332.1
199.0	12101	-63.7				300	57	332.2		332.2
197.0	12162	-64.0				300	58	332.7		332.7
182.0	12641	-66.2				310	31	336.7		336.7
168.0	13125	-68.5				275	22	340.7		340.7
161.0	13383	-69.7				280	35	342.8		342.8
155.0	13612	-66.9				285	45	351.3		351.3
150.0	13810	-64.5				300	34	358.8		358.8
139.0	14282	-58.7				286	16	376.9		376.9
138.0	14328	-58.8				285	14	377.5		377.5
103.0	16157	-61.1				280	7	406.0		406.0
100.0	16340	-61.9				280	6	407.9		407.9
99.8	16352	-62.1				280	6	407.7		407.7
91.0	16922	-62.3				280	4	418.2		418.2
86.0	17270	-62.4				235	14	424.7		424.7
70.0	18540	-62.9				330	3	449.5		449.5
66.0	18901	-63.1				0	0	456.6		456.6
64.0	19090	-63.3				240	8	460.4		460.4
63.3	19158	-63.3				257	8	461.7		461.7
61.0	19386	-61.8				315	7	469.9		469.9
59.6	19529	-60.9				329	7	475.1		475.1
50.0	20620	-60.3				75	6	500.9		500.9
48.0	20875	-60.2				105	6	507.1		507.1
37.0	22500	-59.5				260	10	548.1		548.1
30.0	23810	-58.9				60	2	583.5		583.5
29.9	23831	-58.9						584.0		584.0

Table 5. Radiosonde profile for noon, 23.04.07, Trappes, France

07145 Trappes Observations at 12Z 23 Apr 2007

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1002.0	168	20.8	9.8	49	7.64	280	4	293.8	316.0	295.1
1000.0	185	20.6	9.6	49	7.55	280	4	293.8	315.8	295.1
925.0	851	14.6	7.6	63	7.13	280	6	294.2	315.1	295.5
856.0	1499	8.6	3.6	71	5.82	280	8	294.6	311.7	295.6
850.0	1557	8.6	1.6	61	5.08	280	8	295.1	310.3	296.1
818.0	1874	8.4	-21.6	10	0.84	279	9	298.2	301.0	298.3
777.0	2295	5.0	-9.0	36	2.50	278	10	298.9	306.8	299.4
749.0	2594	4.0	-18.0	18	1.25	277	11	301.0	305.1	301.2
739.0	2703	3.6	-5.4	52	3.48	276	12	301.7	312.6	302.4
715.0	2970	2.6	-26.4	10	0.62	276	12	303.5	305.6	303.6
700.0	3141	1.2	-18.8	21	1.24	275	13	303.8	307.9	304.0
650.0	3734	-3.3	-10.3	58	2.70	275	15	305.2	313.9	305.7
609.0	4247	-7.3	-13.3	62	2.26	275	17	306.3	313.7	306.7
595.0	4429	-8.5	-13.5	67	2.28	275	17	307.0	314.4	307.4
554.0	4980	-12.1	-20.9	48	1.31	275	19	309.0	313.5	309.3
552.0	5008	-12.3	-21.3	47	1.27	276	19	309.1	313.4	309.4
514.0	5552	-15.9	-17.8	85	1.85	301	16	311.1	317.3	311.5
500.0	5760	-17.3	-19.5	83	1.64	310	15	311.9	317.4	312.2
492.0	5878	-18.1	-20.5	82	1.53	315	14	312.3	317.5	312.6
429.0	6883	-25.2	-28.9	71	0.82	290	28	315.8	318.7	315.9
415.0	7126	-26.9	-31.0	68	0.70	304	28	316.6	319.1	316.7
400.0	7390	-27.9	-36.9	42	0.41	320	28	318.6	320.2	318.7
386.0	7645	-28.9	-46.9	16	0.15	334	28	320.6	321.2	320.6
360.0	8133	-33.1	-50.3	16	0.11	0	27	321.4	321.9	321.4
327.0	8806	-38.9	-54.9	17	0.07	3	42	322.4	322.7	322.4
304.0	9300	-43.1				5	54	323.2		323.2
300.0	9390	-43.9				5	54	323.4		323.4
250.0	10590	-54.3				355	53	325.2		325.2
227.0	11198	-59.9				351	53	325.8		325.8
200.0	11980	-62.3				345	52	333.9		333.9
196.0	12105	-62.7				345	52	335.2		335.2
182.0	12564	-64.3				335	43	339.8		339.8
150.0	13770	-59.1				310	20	368.1		368.1
142.0	14115	-57.7				305	13	376.4		376.4
140.0	14204	-57.3				305	13	378.5		378.5
100.0	16310	-60.9				310	12	409.8		409.8
72.3	18312	-63.7				315	12	443.6		443.6
72.0	18337	-63.6				315	12	444.3		444.3
70.0	18510	-63.3				315	11	448.6		448.6
55.9	19910	-59.5				345	4	487.1		487.1
50.0	20610	-59.5				0	0	502.8		502.8
40.0	22003	-59.4				260	8	536.2		536.2
36.0	22660	-59.3				350	8	552.7		552.7
32.8	23241	-59.3				324	8	567.7		567.7
30.0	23800	-58.3				300	8	585.1		585.1
25.0	24960	-56.3				245	7	622.1		622.1
22.0	25774	-54.9				295	7	649.4		649.4
20.0	26380	-53.9				270	7	670.4		670.4
19.8	26444	-53.9				267	7	672.4		672.4
16.6	27567	-56.7				221	7	698.1		698.1
15.0	28219	-53.1				195	7	730.4		730.4
13.6	28849	-49.7				217	9	762.9		762.9
12.0	29672	-48.6				245	12	794.4		794.4
11.0	30244	-47.9				0	0	817.1		817.1
10.0	30870	-47.1				275	9	842.6		842.6
9.5	31210	-46.5				254	9	857.3		857.3
8.0	32366	-41.4				185	8	920.6		920.6
7.7	32623	-40.3						935.3		935.3

Table 6. Radiosonde profile for noon, 23.04.07, Camborne, Cornwall

03808 Camborne Observations at 12Z 23 Apr 2007

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1009.0	88	13.0	12.6	97	9.16	190	12	285.4	310.9	287.0
1008.0	96	12.6	12.3	98	8.99	190	13	285.1	310.1	286.6
1001.0	152	12.0	12.0	100	8.87	193	18	285.1	309.8	286.6
1000.0	160	12.0	12.0	100	8.88	194	19	285.1	309.9	286.7
997.0	185	11.9	11.9	100	8.86	195	21	285.3	310.0	286.9
972.0	398	11.4	11.3	99	8.72	223	27	286.9	311.4	288.4
968.0	432	11.6	11.6	100	8.93	228	28	287.4	312.5	289.0
966.0	450	12.4	12.4	100	9.45	230	29	288.4	315.0	290.0
965.0	459	12.8	12.8	100	9.71	230	29	288.9	316.3	290.6
934.0	733	11.9	11.5	97	9.19	235	31	290.6	316.8	292.2
925.0	814	11.6	11.1	97	9.05	235	30	291.2	317.0	292.8
896.0	1081	11.0	8.0	82	7.56	225	25	293.2	315.2	294.5
882.0	1212	10.1	6.1	77	6.75	220	23	293.6	313.3	294.8
881.0	1222	10.0	6.0	76	6.70	220	23	293.6	313.1	294.8
862.0	1403	8.5	5.2	80	6.48	220	25	293.9	312.9	295.1
850.0	1519	7.6	4.7	82	6.34	230	26	294.1	312.7	295.2
849.0	1529	7.6	4.8	82	6.39	233	26	294.2	312.9	295.3
848.0	1538	7.5	4.8	83	6.39	235	26	294.2	313.0	295.4
826.0	1755	5.8	4.6	92	6.48	235	24	294.6	313.6	295.8
820.0	1814	5.5	4.4	93	6.42	235	24	294.9	313.8	296.0
800.0	2016	4.4	3.6	95	6.23	228	27	295.8	314.2	296.9
792.0	2098	4.1	3.0	92	6.02	225	28	296.4	314.2	297.5
771.0	2317	3.4	1.3	86	5.48	225	29	297.9	314.3	298.9
764.0	2391	2.8	1.1	88	5.44	225	29	298.1	314.4	299.0
751.0	2530	1.8	0.6	92	5.35	225	32	298.4	314.5	299.4
730.0	2758	1.2	-2.6	76	4.35	225	36	300.2	313.5	300.9
726.0	2802	1.2	-1.4	83	4.78	225	37	300.6	315.2	301.5
723.0	2836	0.9	-1.5	84	4.76	225	38	300.7	315.2	301.6
700.0	3095	-1.1	-2.5	90	4.57	230	36	301.2	315.3	302.1
683.0	3291	-2.7	-3.6	94	4.31	233	35	301.6	314.9	302.4
674.0	3396	-3.3	-4.7	90	4.02	235	35	302.1	314.5	302.8
659.0	3574	-4.3	-6.6	84	3.56	231	36	302.9	314.0	303.5
645.0	3743	-5.3	-12.3	58	2.32	228	36	303.6	311.1	304.0
633.0	3890	-6.2	-12.4	61	2.33	225	37	304.2	311.7	304.6
629.0	3939	-6.5	-12.5	62	2.34	225	37	304.4	311.9	304.9
625.0	3989	-6.3	-16.3	45	1.72	225	38	305.2	310.9	305.5
616.0	4102	-6.9	-14.9	53	1.96	225	39	305.8	312.2	306.1
610.0	4179	-7.1	-20.1	35	1.28	225	40	306.4	310.7	306.6
609.0	4191	-7.3	-19.3	38	1.37	225	40	306.3	310.9	306.6
604.0	4256	-7.3	-29.3	15	0.56	225	41	307.0	309.0	307.1
601.0	4294	-7.5	-27.5	18	0.67	225	41	307.2	309.6	307.4
600.0	4307	-7.5	-25.1	23	0.83	225	41	307.4	310.3	307.6
596.0	4359	-7.5	-15.5	53	1.93	223	41	308.0	314.4	308.3
586.0	4491	-8.1	-19.1	41	1.45	216	41	308.8	313.7	309.1
584.0	4517	-8.2	-16.6	51	1.80	215	41	308.9	314.9	309.3
583.0	4531	-8.3	-15.3	57	2.01	215	41	309.0	315.6	309.4
553.0	4938	-10.5	-13.6	78	2.44	230	39	311.1	319.1	311.5
540.0	5122	-11.5	-12.8	90	2.66	228	37	312.0	320.8	312.5
525.0	5337	-12.3	-13.5	91	2.58	226	35	313.6	322.2	314.1
521.0	5396	-12.3	-13.8	89	2.55	225	34	314.2	322.7	314.7
510.0	5559	-12.5	-14.5	85	2.45	225	35	315.9	324.2	316.4
500.0	5710	-13.3	-15.8	81	2.24	225	36	316.8	324.4	317.2
486.0	5925	-14.8	-17.7	78	1.97	230	38	317.6	324.3	317.9
448.0	6541	-18.9	-23.2	69	1.33	216	47	319.8	324.5	320.1
446.0	6574	-19.1	-23.4	69	1.31	215	47	320.0	324.6	320.2
417.0	7073	-22.2	-26.0	72	1.11	225	41	322.2	326.2	322.4
409.0	7217	-23.1	-26.7	72	1.06	227	41	322.8	326.6	323.0
400.0	7380	-24.3	-28.3	69	0.93	230	42	323.3	326.7	323.5
381.0	7729	-27.1	-31.4	66	0.73	235	39	324.2	326.9	324.3
367.0	7998	-29.2	-33.9	64	0.60	235	44	324.8	327.1	325.0
360.0	8136	-30.3	-35.1	63	0.54	235	42	325.2	327.2	325.3
338.0	8577	-33.9	-38.8	61	0.40	235	37	326.2	327.7	326.3
332.0	8703	-34.9	-39.9	61	0.36	235	42	326.5	327.9	326.5
324.0	8873	-36.3	-41.3	60	0.32	242	42	326.8	328.1	326.9
315.0	9067	-38.0	-42.7	61	0.28	250	41	327.1	328.3	327.2
308.0	9221	-39.3	-43.8	62	0.26	246	39	327.4	328.4	327.4
306.0	9265	-39.7	-44.2	62	0.25	245	38	327.4	328.4	327.5
300.0	9400	-40.9	-45.5	61	0.22	245	38	327.6	328.5	327.6
296.0	9490	-41.8	-46.5	60	0.20	245	41	327.6	328.4	327.7
286.0	9720	-44.0	-49.2	56	0.15	240	33	327.7	328.4	327.8
269.0	10131	-47.9	-53.9	50	0.09	255	40	327.8	328.2	327.8
258.0	10404	-49.8	-56.5	45	0.07	265	44	328.9	329.2	328.9
253.0	10532	-50.7	-57.7	43	0.06	265	45	329.4	329.7	329.4
250.0	10610	-51.5	-58.5	43	0.06	265	46	329.4	329.6	329.4

238.0	10924	-54.3	-61.3	42	0.04	270	50	329.8	330.0	329.8
223.0	11340	-58.0	-65.0	40	0.03	275	46	330.3	330.4	330.3
218.0	11485	-59.3	-66.3	40	0.02	274	48	330.5	330.6	330.5
201.0	11989	-63.8	-70.8	38	0.01	270	55	331.1	331.1	331.1
200.0	12020	-64.1	-71.1	38	0.01	275	56	331.1	331.2	331.1
193.0	12238	-65.9	-72.9	37	0.01	275	61	331.6	331.6	331.6
186.0	12463	-63.7	-71.7	33	0.01	284	44	338.7	338.7	338.7
185.0	12496	-63.9	-72.0	32	0.01	285	42	338.9	339.0	338.9
178.0	12731	-65.1	-73.8	29	0.01	275	29	340.7	340.7	340.7
172.0	12940	-66.2	-75.5	26	0.01	260	27	342.2	342.3	342.2
165.0	13193	-67.5	-77.5	23	0.01	254	36	344.1	344.1	344.1
161.0	13341	-67.2	-77.2	23	0.01	250	41	347.1	347.1	347.1
160.0	13378	-67.1	-77.1	23	0.01	253	40	347.8	347.9	347.8
154.0	13609	-67.3	-79.3	17	0.00	273	36	351.3	351.3	351.3
152.0	13689	-65.1	-78.6	14	0.01	280	34	356.4	356.4	356.4
150.0	13770	-62.9	-77.9	12	0.01	275	30	361.5	361.6	361.5
149.0	13811	-62.1	-77.6	11	0.01	275	30	363.6	363.6	363.6
148.0	13853	-61.3	-77.3	10	0.01	270	33	365.7	365.7	365.7
147.0	13895	-61.0	-77.9	9	0.01	265	37	366.8	366.9	366.8
145.0	13981	-60.5	-79.2	7	0.01	270	41	369.2	369.2	369.2
140.0	14200	-59.1	-82.3	3	0.00	285	28	375.3	375.3	375.3
137.0	14336	-58.3	-84.3	2	0.00	265	14	379.1	379.1	379.1
133.0	14522	-58.8	-86.4	2	0.00	245	21	381.5	381.5	381.5
132.0	14570	-58.9	-86.9	2	0.00	249	21	382.1	382.1	382.1
128.0	14763	-58.9	-87.5	1	0.00	265	20	385.6	385.6	385.6
117.0	15327	-58.7	-89.3	1	0.00	260	24	395.8	395.8	395.8
115.0	15436	-58.7	-89.7	1	0.00	270	19	397.8	397.8	397.8
111.0	15657	-59.2	-90.2	1	0.00	255	11	400.9	400.9	400.9
109.0	15771	-59.5	-90.5	1	0.00	235	16	402.5	402.5	402.5
105.0	16005	-60.0	-91.0	1	0.00	265	19	405.8	405.8	405.8
101.0	16248	-60.6	-91.6	1	0.00	260	13	409.3	409.3	409.3
100.0	16310	-60.7	-91.7	1	0.00	255	14	410.2	410.2	410.2
98.0	16436	-60.5	-91.5	1	0.00	250	17	412.8	412.9	412.8
92.2	16815	-60.1	-91.1	1	0.00	275	13	421.0	421.0	421.0
91.0	16896	-60.6	-91.4	1	0.00	280	12	421.6	421.6	421.6
89.0	17033	-61.4	-91.9	1	0.00	250	9	422.8	422.8	422.8
86.0	17245	-62.6	-92.6	1	0.00	240	15	424.5	424.5	424.5
85.7	17267	-62.7	-92.7	1	0.00	241	15	424.6	424.6	424.6
82.0	17538	-62.2	-92.2	1	0.00	255	10	431.0	431.0	431.0
79.7	17714	-61.9	-91.9	1	0.00	282	5	435.2	435.2	435.2
79.0	17768	-62.1	-92.0	1	0.00	290	4	435.8	435.8	435.8
77.0	17925	-62.9	-92.4	1	0.00	220	9	437.5	437.5	437.5
75.0	18087	-63.6	-92.8	1	0.00	230	13	439.3	439.3	439.3
73.6	18202	-64.1	-93.1	1	0.00	240	14	440.6	440.6	440.6
73.0	18252	-63.7	-93.0	1	0.00	245	15	442.5	442.5	442.5
72.0	18337	-63.0	-92.7	1	0.00	255	9	445.7	445.7	445.7
71.3	18397	-62.5	-92.5	1	0.00	250	9	448.0	448.0	448.0
70.0	18510	-62.5	-92.5	1	0.00	240	9	450.3	450.3	450.3
67.0	18781	-61.8	-92.2	1	0.00	220	7	457.5	457.5	457.5
64.0	19065	-61.1	-91.9	1	0.00	230	12	465.1	465.1	465.1
62.3	19232	-60.7	-91.7	1	0.00	261	12	469.6	469.6	469.6
61.0	19363	-61.1	-91.8	1	0.00	285	12	471.5	471.5	471.5
57.8	19697	-62.1	-92.1	1	0.00	241	8	476.6	476.6	476.6
57.0	19783	-61.4	-91.8	1	0.00	230	7	480.0	480.0	480.0
55.7	19927	-60.3	-91.3	1	0.00	117	4	485.7	485.8	485.7
55.0	20006	-60.3	-91.3	1	0.00	55	2	487.6	487.6	487.6
51.0	20477	-60.1	-91.1	1	0.00	235	6	498.5	498.5	498.5
50.0	20600	-60.1	-91.1	1	0.00	255	8	501.4	501.4	501.4
49.0	20726	-60.2	-91.2	1	0.00	295	6	504.2	504.2	504.2
47.0	20986	-60.3	-91.3	1	0.00	185	7	509.9	509.9	509.9
46.7	21026	-60.3	-91.3	1	0.00	199	7	510.8	510.8	510.8
44.0	21396	-60.8	-91.4	1	0.00	330	7	518.4	518.4	518.4
40.2	21957	-61.5	-91.5	1	0.00	283	2	530.2	530.2	530.2
40.0	21988	-61.4	-91.4	1	0.00	280	2	531.2	531.2	531.2
38.0	22309	-60.1	-90.5	1	0.00	245	10	542.4	542.4	542.4
36.0	22647	-58.7	-89.5	1	0.00	300	6	554.3	554.3	554.3
35.1	22805	-58.1	-89.1	1	0.00	272	5	560.0	560.0	560.0
33.0	23192	-58.8	-89.8	1	0.00	205	3	568.2	568.2	568.2
31.3	23524	-59.3	-90.3	1	0.00	302	8	575.4	575.4	575.4
31.0	23584	-59.2	-90.2	1	0.00	320	9	577.2	577.2	577.2
30.0	23790	-58.9	-89.9	1	0.00	75	2	583.5	583.5	583.5
29.0	24004	-58.4	-89.8	1	0.00	245	8	590.5	590.5	590.5
27.5	24339	-57.7	-89.7	1	0.00	278	12	601.5	601.6	601.5
27.0	24455	-57.9	-89.7	1	0.00	290	13	604.0	604.0	604.0
25.1	24915	-58.9	-89.9	1	0.00	233	3	614.0	614.0	614.0
25.0	24940	-58.8	-89.9	1	0.00	230	2	614.9	615.0	614.9
23.6	25303	-57.7	-89.7	1	0.01	247	8	628.4	628.4	628.4
23.0	25466	-57.9	-89.6	1	0.01	255	11	632.4	632.4	632.4
21.5	25892	-58.5	-89.5	1	0.01	277	5	643.0	643.0	643.0
21.0	26041	-57.7	-89.0	1	0.01	285	3	649.6	649.7	649.6
20.0	26350	-56.1	-88.1	1	0.01	275	8	663.7	663.8	663.7

18.6	26812	-54.7	-86.7	1	0.01	11	8	682.0	682.1	682.0
18.0	27022	-55.0	-87.0	1	0.01	55	8	687.4	687.5	687.4
16.8	27462	-55.7	-87.7	1	0.01	128	13	698.9	699.0	698.9
16.2	27694	-53.9	-86.9	1	0.01	167	16	712.0	712.2	712.0
16.0	27774	-53.8	-86.8	1	0.01	180	17	714.8	715.0	714.8
15.0	28189	-53.4	-86.4	1	0.02	215	15	729.5	729.6	729.5
14.7	28318	-53.3	-86.3	1	0.02	227	14	734.1	734.3	734.1
14.0	28634	-52.7	-85.7	1	0.02	255	13	746.3	746.5	746.3
13.0	29112	-51.9	-84.9	1	0.02	325	6	765.2	765.5	765.2
12.8	29212	-51.7	-84.7	1	0.02	352	7	769.3	769.5	769.3
12.0	29630	-51.7	-84.7	1	0.03	105	13	783.6	783.9	783.6
11.3	30020	-51.7	-84.7	1	0.03	153	14	797.1	797.5	797.2
11.0	30196	-50.7	-84.2	1	0.03	175	15	806.8	807.2	806.8
10.0	30820	-47.3	-82.3	1	0.05	185	16	841.9	842.5	841.9
9.4	31231	-45.5	-80.5	1	0.07	203	17	863.7	864.6	863.8
9.0	31520	-46.1	-81.1	1	0.06	215	17	872.1	872.9	872.1
8.9	31594	-46.3	-81.3	1	0.06	216	17	874.2	875.0	874.3
8.0	32307	-43.6	-79.5	1	0.09	230	12	911.9	913.2	912.0
7.9	32391	-43.3	-79.3	1	0.09	230	15	916.5	917.8	916.5
7.7	32564	-40.9	-77.9	1	0.12	230	20	932.9	934.5	932.9
7.3	32930	-37.7	-75.7	1	0.18	230	32	960.2	962.8	960.3
7.0	33220	-36.3	-74.3	1	0.23	230	41	977.6	980.9	977.7
6.7	33523	-37.3	-75.3	1	0.21	234	33	985.7	988.7	985.9
6.0	34293	-31.9	-71.9	1	0.39	245	12	1040.6	1046.3	1040.8
5.4	35040	-30.5	-70.5	1	0.53	222	11	1078.6	1086.7	1079.0
5.2	35308	-31.3	-71.3	1	0.49	214	11	1086.7	1094.2	1087.0
5.0	35586	-30.8	-70.8	1	0.55	205	11	1101.4	1110.0	1101.8
4.7	36026	-29.9	-69.9	1	0.66			1125.0	1135.5	1125.5

Table 7. Radiosonde profile for noon, 23.04.07, Herstmonceux, Sussex.

03882 Herstmonceux Observations at 12Z 23 Apr 2007

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %	MIXR g/kg	DRCT deg	SKNT knot	THTA K	THTE K	THTV K
1015.0	52	12.8	10.7	87	8.02	270	4	284.7	307.1	286.1
1014.0	61	12.4	9.6	83	7.45	268	4	284.4	305.2	285.7
1009.0	103	11.4	9.7	89	7.54	258	6	283.8	304.8	285.1
1003.0	154	10.9	9.8	93	7.65	245	8	283.8	305.1	285.1
1000.0	180	10.6	9.9	95	7.71	240	9	283.8	305.2	285.1
997.0	205	10.3	9.9	97	7.73	240	10	283.7	305.2	285.0
996.0	213	10.2	9.9	98	7.74	241	10	283.7	305.2	285.0
986.0	297	9.8	9.8	100	7.77	248	13	284.1	305.7	285.4
970.0	434	12.4	11.2	92	8.68	260	18	288.1	312.6	289.6
964.0	486	12.2	10.7	91	8.45	265	20	288.4	312.3	289.8
948.0	627	12.7	8.7	77	7.47	260	24	290.2	311.6	291.5
943.0	671	12.8	8.0	73	7.18	258	24	290.8	311.5	292.1
925.0	833	11.4	7.9	79	7.27	250	24	291.0	311.9	292.2
918.0	897	11.0	7.9	81	7.33	248	24	291.2	312.3	292.5
903.0	1034	10.4	7.5	82	7.25	245	25	292.0	312.9	293.2
892.0	1136	10.0	7.2	83	7.19	245	25	292.6	313.4	293.8
883.0	1221	10.2	6.5	78	6.92	245	25	293.6	313.8	294.8
862.0	1421	9.4	5.4	76	6.56	245	25	294.8	314.1	296.0
854.0	1498	8.9	5.3	78	6.60	245	25	295.0	314.4	296.2
850.0	1537	8.6	5.3	80	6.61	245	26	295.1	314.6	296.3
828.0	1753	7.0	3.3	77	5.89	240	25	295.7	313.1	296.7
814.0	1894	6.4	2.8	78	5.78	236	25	296.5	313.7	297.5
808.0	1954	6.0	1.9	74	5.45	235	25	296.7	313.0	297.7
790.0	2139	5.0	-1.0	65	4.52	229	23	297.5	311.2	298.3
777.0	2274	4.6	-11.4	30	2.07	225	22	298.5	305.1	298.9
761.0	2443	2.9	-5.4	55	3.38	220	20	298.4	308.9	299.0
753.0	2528	2.0	-2.3	73	4.31	222	22	298.4	311.5	299.2
741.0	2658	1.4	-3.2	71	4.10	225	25	299.2	311.7	299.9
727.0	2812	0.8	-4.2	69	3.87	239	26	300.1	312.0	300.8
721.0	2878	1.2	-3.4	71	4.15	246	27	301.2	314.0	302.0
712.0	2979	-0.1	-4.3	73	3.92	255	28	300.9	313.0	301.6
709.0	3013	-0.5	-4.6	74	3.85	256	28	300.8	312.7	301.5
700.0	3115	-1.3	-4.6	78	3.90	260	29	301.0	313.1	301.7
693.0	3195	-1.9	-4.4	83	4.00	264	28	301.2	313.6	301.9
692.0	3207	-1.1	-3.3	85	4.35	264	27	302.2	315.7	303.0
665.0	3524	-2.5	-4.5	87	4.15	280	22	304.1	317.0	304.8

662.0	3560	-2.7	-4.6	87	4.13	279	22	304.3	317.2	305.0
644.0	3777	-4.0	-5.5	90	3.97	270	22	305.2	317.6	305.9
605.0	4269	-7.1	-7.4	98	3.64	275	21	307.1	318.7	307.8
602.0	4308	-7.3	-7.7	97	3.59	275	21	307.3	318.8	308.0
587.0	4504	-8.3	-8.9	95	3.34	273	22	308.4	319.1	309.0
549.0	5021	-11.9	-14.6	80	2.26	267	26	310.1	317.5	310.5
535.0	5217	-13.3	-15.5	84	2.14	265	27	310.6	317.8	311.0
504.0	5670	-16.7	-17.7	92	1.90	261	23	311.9	318.3	312.3
500.0	5730	-16.9	-17.4	96	1.96	260	23	312.4	319.0	312.7
493.0	5836	-17.7	-18.1	97	1.88	267	26	312.6	319.0	313.0
486.0	5943	-17.7	-20.7	78	1.53	275	30	313.9	319.2	314.2
484.0	5974	-17.7	-21.4	73	1.44	276	30	314.3	319.2	314.6
474.0	6130	-19.3	-29.3	41	0.72	280	31	314.2	316.8	314.3
465.0	6272	-19.5	-43.5	10	0.18	283	32	315.7	316.4	315.7
460.0	6353	-19.2	-44.8	8	0.15	285	33	317.1	317.7	317.1
459.0	6369	-19.1	-45.1	8	0.15	284	34	317.4	317.9	317.4
455.0	6434	-19.5	-45.0	9	0.15	280	36	317.6	318.2	317.7
442.0	6648	-20.9	-44.5	10	0.16	275	29	318.6	319.2	318.6
423.0	6973	-22.9	-43.9	13	0.18	290	17	320.0	320.7	320.0
400.0	7380	-26.5	-42.5	21	0.23	310	17	320.5	321.4	320.5
391.0	7544	-27.9	-41.9	25	0.25	324	16	320.7	321.7	320.8
387.0	7618	-28.7	-41.0	30	0.28	330	15	320.6	321.7	320.7
384.0	7674	-29.3	-40.3	34	0.30	329	17	320.5	321.7	320.6
370.0	7938	-31.1	-37.1	56	0.43	325	24	321.6	323.2	321.6
355.0	8230	-33.3	-38.3	61	0.40	320	33	322.5	324.0	322.6
352.0	8290	-33.7	-38.5	62	0.39	319	34	322.7	324.2	322.8
327.0	8801	-38.0	-43.0	60	0.26	315	45	323.6	324.6	323.6
318.0	8994	-39.7	-44.7	59	0.23	320	41	323.9	324.8	323.9
310.0	9168	-41.3	-49.6	40	0.13	325	38	324.0	324.6	324.0
306.0	9256	-42.1	-52.1	33	0.10	325	38	324.1	324.5	324.1
300.0	9390	-43.3	-54.3	29	0.08	325	38	324.2	324.6	324.2
289.0	9638	-45.6	-58.0	23	0.05	335	42	324.4	324.6	324.4
284.0	9754	-46.7	-59.7	21	0.04	333	42	324.5	324.6	324.5
268.0	10130	-50.3	-60.9	28	0.04	325	42	324.7	324.8	324.7
252.0	10529	-54.1	-62.1	37	0.04	325	48	324.8	324.9	324.8
250.0	10580	-54.5	-62.5	37	0.03	325	49	324.9	325.1	324.9
235.0	10972	-57.4	-64.9	38	0.03	325	60	326.3	326.4	326.3
222.0	11333	-60.1	-67.1	39	0.02	328	53	327.5	327.6	327.5
214.0	11560	-61.4	-69.5	33	0.02	330	49	328.9	329.0	328.9
208.0	11737	-62.5	-71.3	29	0.01	325	48	330.0	330.0	330.0
200.0	11980	-63.9	-73.9	24	0.01	320	50	331.4	331.5	331.4
193.0	12198	-64.7	-74.7	24	0.01	315	52	333.5	333.5	333.5
190.0	12293	-65.1	-75.1	24	0.01	315	50	334.4	334.4	334.4
178.0	12691	-64.5	-76.5	18	0.01	310	45	341.6	341.7	341.6
174.0	12830	-62.9	-76.9	14	0.01	307	37	346.5	346.6	346.5
171.0	12937	-63.5	-78.7	11	0.00	305	31	347.2	347.3	347.2
169.0	13009	-63.9	-79.9	10	0.00	305	33	347.8	347.8	347.8
165.0	13157	-62.6	-80.8	7	0.00	305	36	352.4	352.4	352.4
156.0	13505	-59.5	-82.9	3	0.00	300	23	363.4	363.4	363.4
155.0	13545	-59.1	-83.1	3	0.00	300	23	364.6	364.6	364.6
150.0	13750	-59.1	-86.1	2	0.00	300	25	368.1	368.1	368.1
145.0	13962	-59.5	-88.5	1	0.00	300	23	370.9	370.9	370.9
143.0	14050	-58.5	-88.5	1	0.00	300	22	374.2	374.2	374.2
139.0	14228	-59.7	-89.7	1	0.00	300	20	375.1	375.1	375.1
134.0	14459	-58.5	-89.2	1	0.00	300	17	381.1	381.1	381.1
129.0	14698	-57.3	-88.7	1	0.00	270	13	387.5	387.5	387.5
125.0	14897	-56.3	-88.3	1	0.00	305	12	392.8	392.8	392.8
122.0	15050	-57.0	-88.7	1	0.00	285	14	394.3	394.4	394.3
116.0	15368	-58.3	-89.7	1	0.00	285	19	397.5	397.5	397.5
112.0	15590	-59.3	-90.3	1	0.00	296	20	399.7	399.7	399.7
107.0	15876	-59.2	-90.2	1	0.00	310	22	405.2	405.2	405.2
104.0	16054	-59.1	-90.1	1	0.00	299	12	408.7	408.7	408.7
103.0	16115	-59.3	-90.3	1	0.00	295	9	409.4	409.4	409.4
100.0	16300	-59.9	-90.9	1	0.00	300	12	411.7	411.7	411.7
98.0	16426	-60.1	-91.1	1	0.00	305	13	413.6	413.6	413.6
94.0	16686	-60.6	-91.7	1	0.00	305	4	417.6	417.6	417.6
93.6	16713	-60.7	-91.7	1	0.00	301	4	418.0	418.0	418.0
90.0	16955	-62.6	-92.9	1	0.00	260	9	418.9	418.9	418.9
88.8	17039	-63.3	-93.3	1	0.00	280	10	419.1	419.1	419.1
86.0	17236	-63.2	-93.2	1	0.00	330	10	423.3	423.3	423.3
85.0	17308	-63.1	-93.1	1	0.00	335	8	424.8	424.8	424.8
81.0	17605	-62.9	-92.9	1	0.00	335	14	431.1	431.1	431.1
80.7	17627	-62.9	-92.9	1	0.00	333	14	431.6	431.6	431.6
78.0	17838	-61.5	-92.1	1	0.00	310	11	438.6	438.6	438.6
75.6	18032	-60.3	-91.3	1	0.00	337	9	445.1	445.1	445.1
74.0	18165	-60.9	-91.6	1	0.00	355	7	446.6	446.6	446.6
70.0	18510	-62.5	-92.5	1	0.00	265	6	450.3	450.3	450.3
69.2	18581	-62.9	-92.9	1	0.00	272	8	451.0	451.0	451.0
67.0	18781	-61.2	-92.2	1	0.00	290	15	458.7	458.7	458.7
66.8	18799	-61.1	-92.1	1	0.00	291	15	459.4	459.4	459.4
62.0	19264	-60.6	-91.6	1	0.00	310	13	470.4	470.5	470.4

61.2	19344	-60.5	-91.5	1	0.00	328	11	472.4	472.4	472.4
60.0	19467	-61.0	-91.7	1	0.00	355	9	473.9	473.9	473.9
58.2	19657	-61.9	-91.9	1	0.00	324	10	476.1	476.1	476.1
58.0	19678	-61.9	-91.9	1	0.00	320	10	476.6	476.6	476.6
56.0	19896	-61.6	-91.8	1	0.00	330	4	482.1	482.1	482.1
55.0	20008	-61.4	-91.8	1	0.00	290	6	484.9	484.9	484.9
52.0	20356	-60.9	-91.7	1	0.00	320	3	493.9	493.9	493.9
50.6	20526	-60.7	-91.7	1	0.00	247	4	498.3	498.3	498.3
50.0	20600	-60.9	-91.9	1	0.00	215	4	499.5	499.6	499.5
49.0	20725	-61.0	-92.0	1	0.00	160	5	502.3	502.3	502.3
46.0	21118	-61.1	-92.1	1	0.00	260	2	511.0	511.0	511.0
43.3	21493	-61.3	-92.3	1	0.00	292	6	519.5	519.5	519.5
41.0	21833	-60.0	-91.0	1	0.00	320	9	530.9	530.9	530.9
39.8	22018	-59.3	-90.3	1	0.00	328	9	537.2	537.2	537.2
38.6	22209	-59.7	-90.7	1	0.00	336	8	540.9	540.9	540.9
38.0	22308	-59.6	-90.6	1	0.00	340	8	543.6	543.6	543.6
37.0	22475	-59.4	-90.4	1	0.00	335	1	548.2	548.2	548.2
34.0	23005	-58.9	-89.9	1	0.00	225	11	563.0	563.0	563.0
33.0	23192	-58.7	-89.7	1	0.00	265	12	568.3	568.4	568.3
31.0	23584	-58.3	-89.3	1	0.00	0	1	579.6	579.7	579.6
30.0	23790	-58.1	-89.1	1	0.00	270	4	585.7	585.7	585.7
29.2	23960	-58.1	-89.1	1	0.00	290	5	590.2	590.2	590.2

29.0 295 5

Table 8. Radiosonde ascent Station Information and Sounding Indices

Herstmoceux Station information and sounding indices

Station number: 3882
Observation time: 070423/1200
Station latitude: 50.90
Station longitude: 0.32
Station elevation: 52.0
Showalter index: 2.66
Lifted index: 6.82
LIFT computed using virtual temperature: 6.95
SWEAT index: 195.93
K index: 27.50
Cross totals index: 22.20
Vertical totals index: 25.50
Totals totals index: 47.70
Convective Available Potential Energy: 0.00
CAPE using virtual temperature: 0.00
Convective Inhibition: 0.00
CINS using virtual temperature: 0.00
Bulk Richardson Number: 0.00
Bulk Richardson Number using CAPV: 0.00
Temp [K] of the Lifted Condensation Level: 283.08
Pres [hPa] of the Lifted Condensation Level: 970.22
Mean mixed layer potential temperature: 285.56
Mean mixed layer mixing ratio: 7.98
1000 hPa to 500 hPa thickness: 5550.00
Precipitable water [mm] for entire sounding: 26.87

Camborne Station information and sounding indices

Station number: 3808
Observation time: 070423/1200
Station latitude: 50.22
Station longitude: -5.32
Station elevation: 88.0
Showalter index: 7.40
Lifted index: 7.69
LIFT computed using virtual temperature: 7.82
SWEAT index: 144.38
K index: 24.20
Cross totals index: 18.00
Vertical totals index: 20.90
Totals totals index: 38.90
Convective Available Potential Energy: 0.00
CAPE using virtual temperature: 0.00
Convective Inhibition: 0.00
CINS using virtual temperature: 0.00

```
                     Equilibrum Level: 969.25
 Equilibrum Level using virtual temperature: 969.25
               Level of Free Convection: 978.52
         LFCT using virtual temperature: 978.52
                 Bulk Richardson Number: 0.00
      Bulk Richardson Number using CAPV: 0.00
  Temp [K] of the Lifted Condensation Level: 285.09
Pres [hPa] of the Lifted Condensation Level: 978.52
     Mean mixed layer potential temperature: 286.88
              Mean mixed layer mixing ratio: 9.05
              1000 hPa to 500 hPa thickness: 5550.00
Precipitable water [mm] for entire sounding: 29.39
```

Trappes Station information and sounding indices

```
                             Station number: 7145
                           Observation time: 070423/1200
                           Station latitude: 48.77
                          Station longitude: 2.02
                          Station elevation: 168.0
                            Showalter index: 4.89
                               Lifted index: 1.74
    LIFT computed using virtual temperature: 1.73
                                SWEAT index: 50.20
                                    K index: 7.50
                         Cross totals index: 18.90
                      Vertical totals index: 25.90
                        Totals totals index: 44.80
      Convective Available Potential Energy: 0.00
             CAPE using virtual temperature: 0.00
                      Convective Inhibition: 0.00
             CINS using virtual temperature: 0.00
                     Bulk Richardson Number: 0.00
          Bulk Richardson Number using CAPV: 0.00
  Temp [K] of the Lifted Condensation Level: 279.94
Pres [hPa] of the Lifted Condensation Level: 843.35
     Mean mixed layer potential temperature: 293.93
              Mean mixed layer mixing ratio: 7.41
              1000 hPa to 500 hPa thickness: 5575.00
Precipitable water [mm] for entire sounding: 18.92
```

Brest Station information and sounding indices

```
                         Station identifier: LFRB
                             Station number: 7110
                           Observation time: 070423/1200
                           Station latitude: 48.45
                          Station longitude: -4.42
                          Station elevation: 95.0
                            Showalter index: 7.73
                               Lifted index: 12.67
    LIFT computed using virtual temperature: 12.87
                                SWEAT index: 123.50
                                    K index: 14.10
                         Cross totals index: 15.30
                      Vertical totals index: 23.30
                        Totals totals index: 38.60
      Convective Available Potential Energy: 0.00
             CAPE using virtual temperature: 0.00
                      Convective Inhibition: 0.00
             CINS using virtual temperature: 0.00
                     Bulk Richardson Number: 0.00
          Bulk Richardson Number using CAPV: 0.00
  Temp [K] of the Lifted Condensation Level: 274.29
Pres [hPa] of the Lifted Condensation Level: 828.60
     Mean mixed layer potential temperature: 289.44
              Mean mixed layer mixing ratio: 5.23
              1000 hPa to 500 hPa thickness: 5572.00
Precipitable water [mm] for entire sounding: 17.24
```

Appendix D: Jersey weather radar, investigation of propagation conditions

The clean nature of the beam-0 images was noted, specifically the absence of sea return. Some weather radars (e.g. the NEXRAD WSR-88D) operate with reduced sensitivity in certain modes, but inquiries confirmed that there is no other scan mode available in this case, the sensitivity being comparable in practice to the NEXRAD clear-air mode. Clutter removal is understood to be limited to the synthetic beam-S images. The fact that much of the beam-0 echo clearly corresponds to echo from island and coastal features,[182] the very features that would be on any permanent clutter map, seems to confirm this. So we think we are seeing all the data there are, without software manipulation, and that the images represent the actual clutter conditions of interest for our investigation.[183]

A minimal amount of sea return on the beam-0 cut might be consistent with the absence of severe radar super-refractivity. Variable weather factors determine wave slope and orientation and thereby the intensity of sea return. We learned from Tony Pallot that sea return is rarely very significant on the Jersey radar, perhaps indicating typically small wave heights and swell amplitudes due to the sheltering effect of the Brittany peninsula and a short southerly wind fetch.

To check conditions on the day, records of the local sea state were sought. The Channel Islands Shipping Forecast issued by Jersey Met Office at noon, 23 April 2007 (*Appendix C*) gives the sea state as "smooth or slight" with no significant swell. This corresponds to World Meteorological Organisation code 2 or 3, defined as "smooth (wavelets) 0.1 to 0.5 m" or "slight 0.5 to 1.25 m" (codes 0 & 1 are "calm, glassy" and "calm, rippled").

Time (Z)	Sig. wave (m)*	Period (s)	Max. wave (m)
1300	0.67	6.30	1.00
1400	0.70	6.70	1.28
1500	0.69	6.90	1.34

**Significant wave height is the mean height of highest 1/3 of waves*

Table 1. Measured wave parameters off Corbiere, Jersey

This forecast was confirmed by values from the Jersey Fisheries wave meter, a waverider buoy situated approximately 6 miles off Corbiere, SW Jersey. As shown in *Table 1*, the maximum wave height at 1400Z was measured at 1.28m with a period of 6.7 sec. This corresponds to a very shallow wave slope in the order of only one or two degrees and very little radar backscatter.

So absence of sea return is not probative evidence. However the absence of any return from the island of Alderney offers a possible independent test. We know that many parts of nearby coasts

[182] On each of the scans the echo appears to be displaced by several kilometres in relation to the geographical map overlay. The reason for this is unknown, but a similar displacement (though even larger) is noted by Rico-Ramirez, Cluckie & Shepherd (*note 183*) in studies using Jersey weather radar images. No attempt has been made to correct this.

[183] If we were seeing higher-elevation data that have been inserted to mitigate clutter in permanent clutter areas then we would expect to find a closely similar echo distribution on a higher elevation cut. But droplets or ice crystals in suspension aloft and yet closely matching the surface clutter distribution would be meteorologically un likely, and in fact none of the higher cuts shows the same pattern or intensity of echo.

and islands are detectable above the radar horizon on beam-0, so two avenues were explored to determine the significance of the absence of echoes returned by Alderney. Evidence was sought regarding the past frequency of detection of echoes from Alderney, and the local radar horizon in standard propagation conditions[184] was compared with the range and elevation AMSL of the island.

The typical frequency of detectability of Alderney was estimated from two sources: Anecdotal evidence from experienced users and a published study of accumulated rainfall measurements using the Jersey weather radar.

Tony Pallot was not surprised by the absence of echo from Alderney, suggesting that its low elevation was probably below the radar horizon. According to his recollection Alderney was almost never detected, even in strongly anticyclonic conditions when AP due to severe temperature inversion "occasionally" shows Guernsey and the French mainland. However the beam-0 scans on the subject date (and to a lesser extent higher elevation scans as well) clearly do show echo from Guernsey, and from the French mainland as well, even though the meteorological conditions appear not to suggest severe AP conditions on April 23 (*Section 5*). Indeed Tony Pallot's own opinion was that negligible radar AP was likely. So this merited further investigation.

The height AMSL of the Jersey weather radar was determined to be 84.2m (276 ft) at the antenna boresight. The horizon distance *d* to which a sea-level reflector would be detectable by centimetric radar in normal propagation conditions, neglecting topographical masking, is given approximately by

$$d(nmi) = 1.23\sqrt{h(ft)}$$

or d = 20nmi. Alderney is ~30nmi from Jersey. However at that distance any reflector higher than about 20m (65 ft) would be above the radar horizon. Alderney is 88m (289 ft) elevation AMSL at the airport runway, and the horizon distance for a reflector at this height in the same conditions is ~41nmi, significantly greater than the 30nmi range of Alderney. So one would expect echoes from Alderney except in sub-refractive propagation conditions, unless at very low beam angles there is physical masking of the radar in the direction of Alderney due to local topography.

To clarify this matter, images of the accumulated echo from beam-0 scans of the same radar during a comparable seasonal period in 2004 were examined. In a four month study by Rico-Ramirez *et al.* of precipitation measurement accuracy using the Jersey weather radar, composite images were compiled of the aggregate echo detected in each of the four elevation scans during the months of February, March, April and May 2004.[185]

[184] Propagation of radar waves is determined by the vertical structure of the atmosphere. The typical pressure, temperature and humidity gradients of the "standard" atmosphere result in a downward refraction. This has the effect of making the distance to the radar horizon greater than the normal optical horizon. When the vertical pressure, temperature and humidity gradients are non-standard, effects analogous to optical mirage can occur. Super-refraction (greater than normal downward bending) expands the radar horizon still further; sub-refraction (upward bending) contracts the radar horizon.

[185] Miguel Angel Rico-Ramirez, Ian Cluckie & Geoff Shepherd, 'Jersey Radar Experiment; Interim Report', *Water and Environmental Management Research Centre, Dept of Civil Engineering*, *University of Bristol,* April 2005.

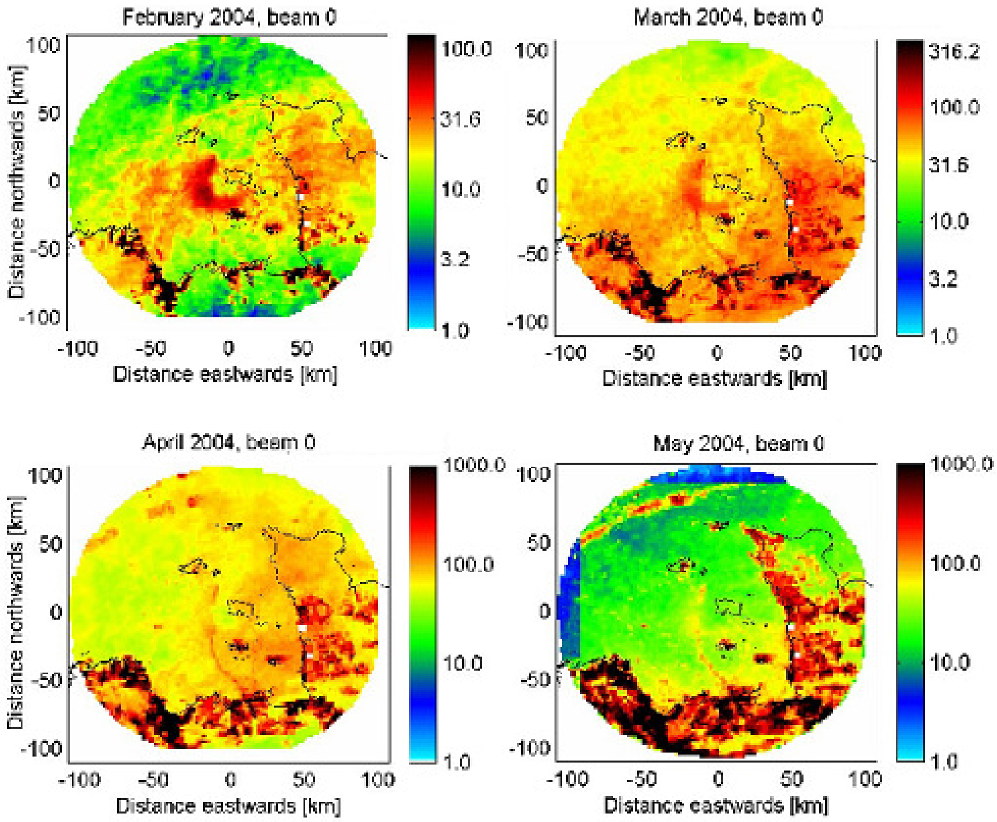


Fig.1 Monthly accumulated echo on Jersey weather radar (beam-0, 0.5° elevation) during Feb-May 2004 (after Rico-Ramirez et al.)

On these accumulated monthly scans (see *Fig.1*) a NE masking sector in the sea return is very evident. But this sea return is in a part of the beam radiating at small negative elevations just beyond the half-power (3dB-down) points of the 1.0° beam.[186] The topographic masking in this part of the beam is not necessarily indicative of raypaths at the main beam boresight elevation of +0.5°. And in fact we do see echo from Alderney on the beam-0 scans.

The possibility that ground clutter has been subtracted and that this echo is very intense local precipitation echo seems small. (The above authors allude to a possible clutter map used by Jersey Met, but this seems to refer to the map used to insert higher-elevation data in the synthetic S beam product referred to above.) Many echoes on the beam-0 scan are clearly clutter from coasts and islands and are identified as such by Rico-Ramirez *et al*., so there is no evidence that a permanent clutter map has been subtracted or substituted in these images. The strong echo accumulated at Alderney, especially in the April and May beam-0 scans, appears therefore to be ground echo.[187]

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[186] The range of the outer edge of this arc of return is quite close to the theoretical sea level horizon distance of about 20nmi [38km] expected in typical propagation conditions, and so corresponds roughly to rays launched at 0°## elevation. This coincides with the -3dB level for a boresight elevation of 0.5°. The inner edge is perhaps 0.9°#from the boresight

[187] The Jersey ground clutter pattern is further discussed by Rico-Ramirez, Cluckie, Shepherd & Pallot, "A High-

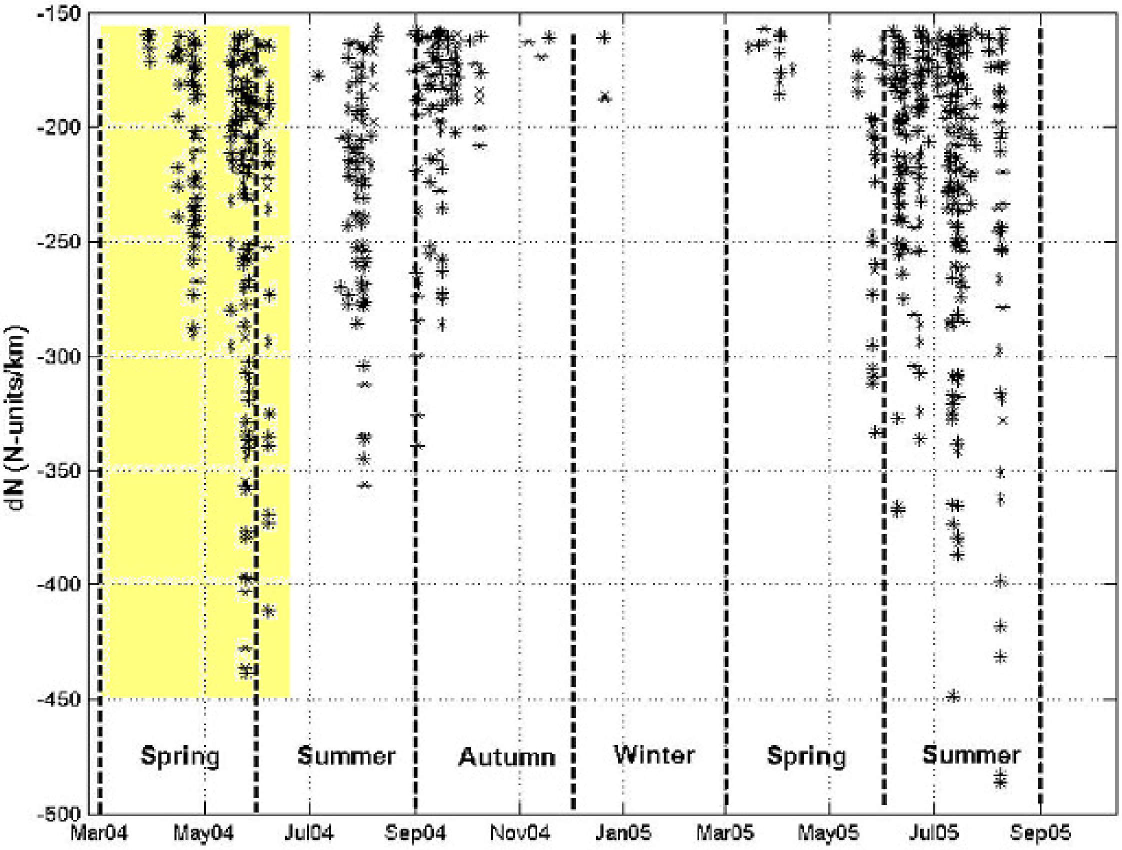

Fig.2 Frequency of radar refractive index gradients (N-units/km) in the Channel Islands area, calculated from radiosonde readings from March 2004 - September 2005. Note the increasing trend through the period (highlighted) of the Rico-Ramirez study. (After Gunashekar et al.)

In support of this we can observe how the echo pattern changes. Generally, the intensity of the local arc of sea return progressively diminishes (relative to the general background) from February to May. This suggests decreasing average wave slope (linearly proportional to a decreasing average wind speed). At the same time distant land clutter and echo from surface vessels[188] intensifies. During April the Alderney echo first becomes clear; in May it is strong. The

Resolution Radar Experiment on the Island of Jersey", *Journal of Meteorological Applications* 14: 117-129 (2007). DOI: 10.1002/met.13

188 Accumulated echo along Ferry routes from St Malo on the Brittany coast is evident, as also is a broader arc of strong echo running up the Channel roughly ESE-WNW to the north of Alderney, which is almost certainly a busy merchant sea lane on which hundreds of large container vessels pass every day.

same trend of intensification is apparent in the echo from Guernsey, suggesting an increasing seasonal frequency of super-refractivity (or decreasing sub-refractivity) causing an expansion of the radar horizon. On the other hand no parallel trend appears in the Jersey mean rainfall figures which for Feb-May 2004 were 37.1, 35.8, 75.4 and 29.9mm.[189]

Finally, the frequency of radar ducting events in the Channel Islands area during the same 2004 period was estimated in a separate study by Gunashekar *et al.*[190] A graph of refractive index gradients in N-units/km calculated from high-resolution radiosonde readings (*Fig.14*) shows a steeply increasing trend through the period March - June 2004, as inferred above, and this trend is paralleled by directly measured variations in 2GHz signal strength over the path between Jersey and Alderney, as well as by modified surface refractivity inversions between the heights of Guernsey and Alderney airports.

In short, the aggregated 2004 observations provide convincing evidence that the strength of ground clutter echo from Alderney was positively correlated with an increasing parabolic curvature of the radar ray paths in conditions of increasing average super-refractivity.

On 23 April 2007 we have evidence of two different inversion regimes, a severe one in the south near the Breton coast and another, much weaker, in the Channel Islands area. Considering the latter, we expect a small surface inversion of perhaps 2°- 3°C/kft in the area. This would by rule-of-thumb be expected to contribute a couple of N-units of refractive index[191]. And the semi-permanent evaporation duct produces as a matter of course a super-refractive (for radio waves only) humidity lapse through the lowest few tens of metres. We might therefore expect to see radar evidence of a small degree of super-refractivity on low elevation cuts, but certainly not much.

So the fact that Alderney does not appear in the radar picture on 23 April can be interpreted as evidence that the latter does not indicate severe radar super-refractivity in the north Channel Islands area, consistent with expectation (from the horizon calculations), with the non-radar meteorological data (lack of evidence for significant temperature inversion in the North Channel Islands area) and with the professional opinions solicited.

But radar evidence of propagation conditions in the south over the French terrain on 23 April 2007 is more ambiguous. There is some variation in the ground clutter intensity during the 30 minutes covered by *Figs. 15-17* in *Section 5*, and this can be interpreted in terms of varying refractivity. An observed diminution in the clutter pattern seems to indicate *de*creasing earthward bending of raypaths (i.e. a transition in the direction of less super-refractive or more sub-refractive conditions). Comparing this clutter pattern with the 2004 images in *Fig.1* might suggest that it is somewhat more intense than would be expected in conditions that give rise to the observed Channel Islands echo pattern, since the latter are monthly accumulations of echo that presumably include (unlike the April 23 images) at least some low-level precipitation over the Breton hills. But the comparison is very subjective.

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189 Jersey Met Office climate records: http://www.jerseymet.gov.je/

190 S.D.Gunashekar, E.M. Warrington, D.R. Siddle and P. Valtr , 'Signal strength variations at 2 GHz for three sea paths in the British Channel Islands: detailed discussion and propagation modelling', *Radio Sci.*, 42, RS4020. http://www.agu.org/pubs/crossref/2007/2006RS003617.shtml

191 An N-unit is one part per million of refractive index, i.e., $N = (n - 1)10^6 = 350$ where $n = 1.00035$. Around 350 N-units is a typical refractivity for centimetric radar at sea level, but it can vary from about 250 to 450 N-units.

We were interested to see if it would be possible to make a more controllable and quantifiable test of the radio propagation conditions by comparing the observed echo pattern with that predicted by a computer simulation. Our hope also was that the result could be extrapolated to infer limits on possible refractivity at optical wavelengths. If so it might be possible to supplement meteorological evidence by means of indirect observational evidence, with a bearing on the possibility of optical mirage and related theories discussed in *Section 6.d*.

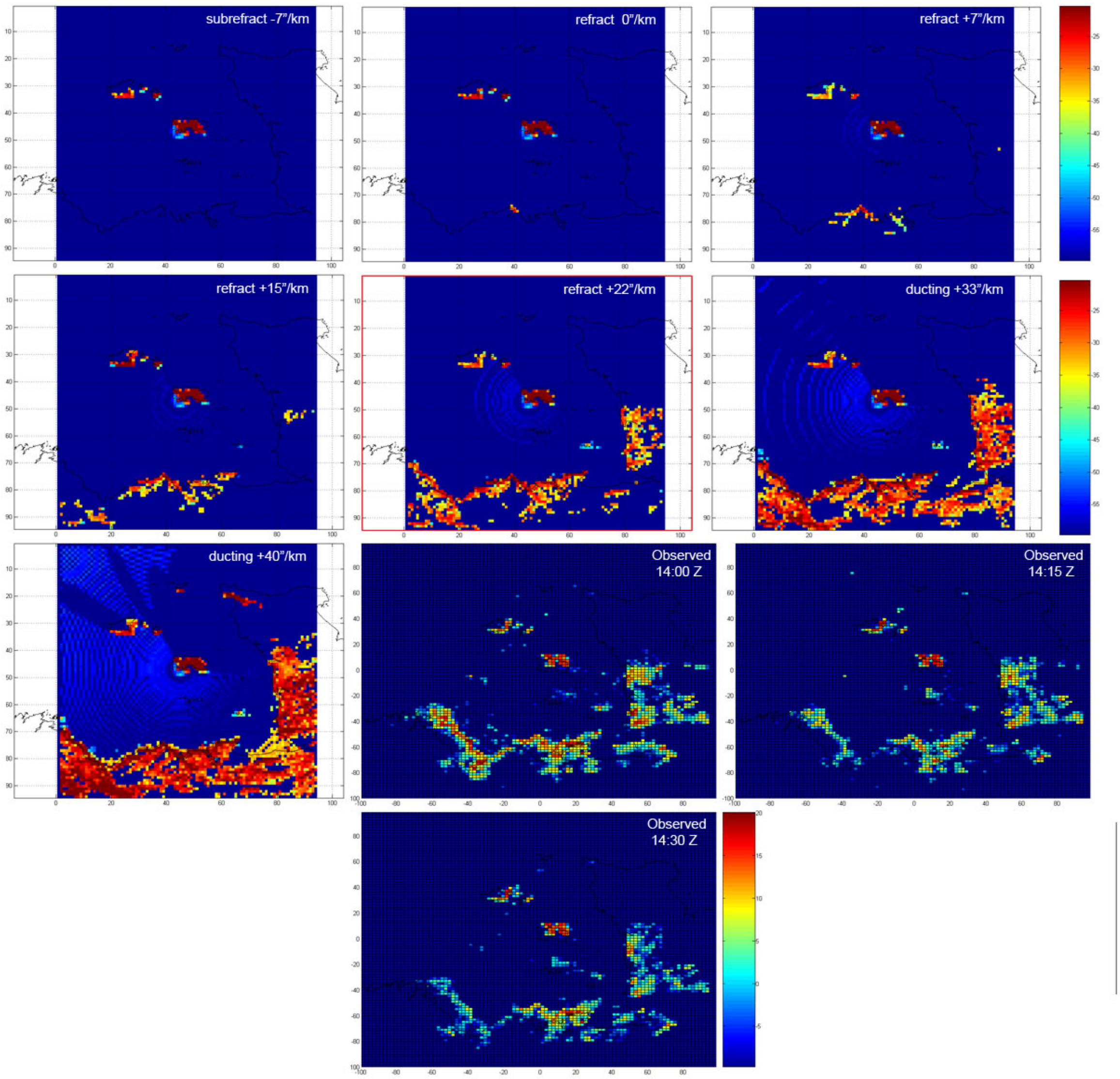

Fig.3 Effects of seven radar refraction values from -7"/km to +40"/km simulated over a digital elevation model, compared with actual clutter patterns (lower right) observed by Jersey Weather Radar 23 April 2007

With this in mind we proceeded to design a computer ray-tracing simulation of the Jersey weather radar coverage pattern for various refractivity values.[192] The simulation was initially run over a digital elevation model (DEM) of the coverage area at 90m resolution, later coarsened to match the 2km pixel resolution of the Jersey weather radar images. The refraction values chosen were -7"/km, 0"/km, +7"/km, +15"/km, +22"/km, +33"/km and +40"/km (positive values indicating bending towards the earth). Initial results for a 0.5 degree ray tracing (*Fig.3*) suggest that the best fit is a refraction of +22"/km, reproducing the 23 April images rather well within the limits of what is necessarily a very approximate simulation in terms both of terrain reflectivity and propagation. This amount of ray refraction, 11"/km less than the earth curvature of 33"/km, is not far from the refraction assumed in the '4/3 earth' approximation used to model propagation in a standard atmosphere.

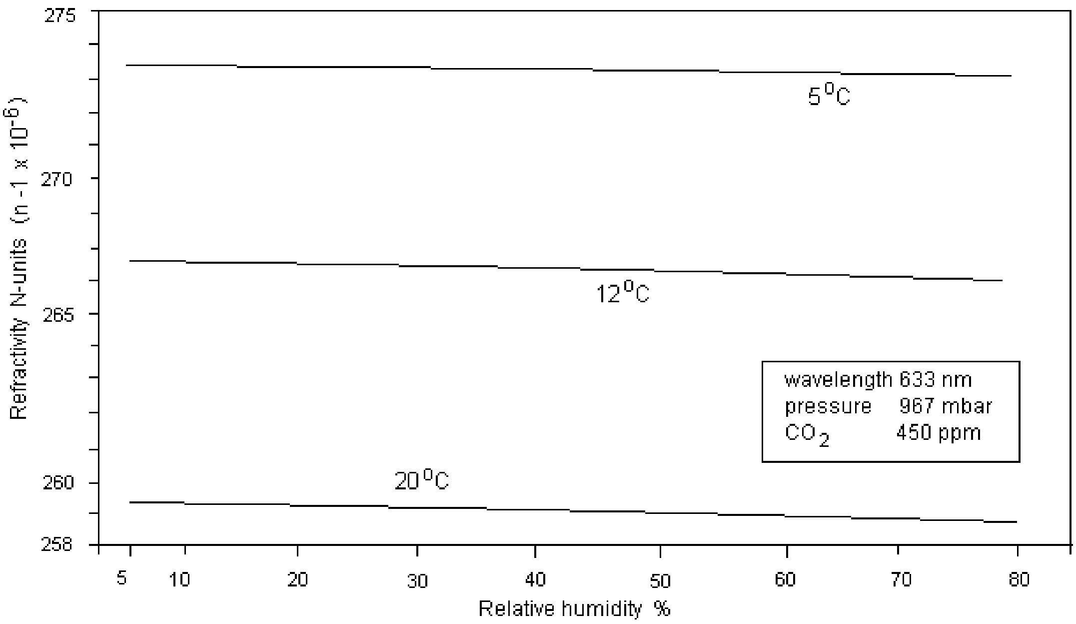

Fig.4. Refractivity of visible light (633 nm) as a function of RH for three temperatures at constant atmospheric pressure (Ciddor equation) showing negligible dependency.

Clearly we should not expect to be able to capture complex and dynamic propagation conditions very effectively in such a crude simulation. But it is still reasonable to be a little surprised at the result. Given evidence of a significant advection inversion close to the Breton shore during the sighting period, with a marginally-ducting gradient of ~10°C/kft based on the Meteo-France

192 The simulation implements the basic radar equation for average received power with an attenuation correction factor for plane (area) targets (i.e. the Earth's surface), the solution being computed for each 90m surface element of the DEM being impacted by a ray. A backscattering algorithm checks where the ray impacts the surface of the DEM and applies the relevant (calm sea/land texture) backscattering profile. For the visualization of the clutter maps we used geocontours included in the Jersey weather radar BUFR decoding package (thanks to Miguel Angel Rico-Ramirez, Bristol U.), rescaled, recentred and rotated by 2° anticlockwise to fit the DEM, with clutter maps downgraded from the 90m resolution to match the 2 km resolution of the Jersey radar. The results (*Fig.3*) show the interplay between the antenna gain diagram (vertical polar profile, boresight elevation 0.5°), distance attenuation, and backscattering efficiency, for different refraction strengths.

numerical simulation and other circumstantial evidence, ought not the low-beam clutter pattern on mainland Brittany to show signs of stronger refractivity than a fairly bland 22"/km?

One possible explanation is that whereas optical refractivity is almost totally insensitive to moisture (*Fig. 4*), the same is not true of radar. In fact variation in humidity contributes far more to the radar refractive index than does variation of temperature.

A semi-permanent feature of the marine radio environment in almost all conditions is the well-studied evaporation duct caused by a humidity lapse over the sea.[193] The effective duct height itself may only be a few tens of metres from the point of view of radio propagation. The question is whether the humidity lapse continues through the marine surface boundary layer (which we take to be in this case the region below the haze discontinuity at about 2000 ft associated with the continental dry air intrusion; see *Section 5*), or whether there might be an *increase* in moisture with height. Radar sub-refraction might occur if there a rising humidity gradient, and thus the radio effects of a small or even moderate temperature inversion could in principle be negated by a humidity "inversion".

Evidence from the Brest radiosonde shows no such gradient, rather there is a somewhat dry boundary layer overlain by the much drier layer already mentioned. The Trappes profile, far to the E and much further from the sea, does show some increase in humidity with height. However our understanding (*Section 5*) is that Brest, an essentially marine environment within the warm sector between fronts and in the same SSW low level airflow, is more representative for our purposes.

The noon Brest radiosonde ascent shows RH at 52% at the surface and <40% through the first 3000ft, which is quite dry, falling to an unusually dry 10% at about 2000ft, perhaps indicating that hygroscopic haze aerosols at this altitude - the same altitude as the reported Channel Islands haze layer - are drying the air. Such a haze is basically composed of airborne particulates whose optical cross-section is dependent on moisture but does not generally indicate RH at saturation or above.

Hygroscopic salt particles in a salt sea haze begin to swell at about 70% RH, but dusts and biological aerosols such as pollen will react to a lower RH than this. The latter is the type of "continental bad air" haze indicated ("not a salt haze") by observers, so a moderate optical thickness in this case indicates removal of moisture from air that is probably well below saturation in the first place. At the sighting time, Guernsey surface RH was recorded at 59% (17°T, 9°D), and Alderney surface RH at 77% (14°T, 10°D). The mean of these values is 68%, only a little below the 22-year historical April average for Guernsey[194] of 73%. The condensation level (cloud base) is close to the freezing level at 10,000ft.

So, tentatively, we would say there is no sign of humidity increasing unusually with height and therefore (though this is far from conclusive) no evidence of a subrefractive humidity gradient that might mask the effects of an expected super-refractive temperature gradient. It is therefore a test of our met model to see if it can explain the unexpected distribution of ground clutter in another way.

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193 Gunashekar *et al.*, op. cit.
194 http://www.met.reading.ac.uk/~brugge/ukclimate.html#HChannel%20Islands

We think that this may be due to the shallowness of the coastal radio duct indicated by the Meteo-France ALADIN simulation combined with the Breton topography. In this model the temperature inversion gives way sharply to an overlying layer with a slightly excessive temperature lapse rate. So the duct traps rays launched at near 0° elevation and at very small negative angles (including some rays scattered at grazing incidence from the surface of the sea) and guides these over the geometrical horizon towards the land. Rays launched at small positive angles just too steep to couple into the duct either continue freely and do not refract earthward at all, or else intercept the top of the duct at a grazing angle and may be scattered by partial reflection back into the sky. Thus the duct acts to introduce a height cut-off in transmitter and receiver gain and tends to reject rays that impact the terrain at altitudes above the top of the duct.

The explanation of the observed clutter pattern could therefore be that the duct is enhancing echo *strength* returned from the terrain, but by the same token is restricting the *area* from which ground echo is receivable. The result is simultaneously to intensify and to contract the clutter pattern, favouring lower terrain, which in N Brittany means that clutter would tend to concentrate towards the coast and be minimised from higher ground inland. Thus a super-refractive surface duct which in theory expands the radar horizon produces, because it is capped below the maximum topography, an effect which resembles the contraction of the radar horizon due to subrefractive conditions.

In the ALADIN model the top of the inversion would be at about 200m ASL. From examining the Breton topography it is our impression that, if this explanation is correct, the effective top of the radio duct may have been somewhat below the 200m contour.

The above evidence and interpretation appears to confirm, or at least increases our confidence in, the meteorological picture developed in *Section 5*.
