

Six objects reported at 480 mph in a declassified military infrared video show brightness flicker at bird wingbeat rates

Jacob Haqq-Misra^{1*}, Ravi Kopparapu², Richard Cloete³,
Omer Eldadi³, Michael Shermer⁴, Abraham Loeb³

^{1*}Blue Marble Space, Seattle, WA, USA.

²NASA Goddard Space Flight Center, Greenbelt, MD, USA.

³Galileo Project, Harvard University, 60 Garden Street, Cambridge, MA, USA.

⁴The Skeptics Society, Santa Barbara, CA, USA.

*Corresponding author(s). E-mail(s): jacob@bmsis.org;
Contributing authors: ravikumar.kopparapu@nasa.gov;
richard.cloete@cfa.harvard.edu; omereldadi@gmail.com;
mshermer@skeptic.com; aloeb@cfa.harvard.edu;

Abstract

In September 2026 the U.S. Department of War released an infrared video recorded from a military aircraft over the Middle East, with a mission report describing six small spherical objects moving at an estimated 480 miles per hour. We measure the brightness of each object in every frame. All six brighten and dim steadily at 7.1–7.9 times per second, each at its own rate and out of step with the others. Tests with planted constant-brightness objects show that neither compression nor the sensor produces this flicker. The same analysis, applied to the Galileo Project’s ground-based infrared cameras near Las Vegas, finds flying animals beating steadily at 3.4–10.0 times per second, within the range of bird wingbeats. A nearly stationary object at 60–80% of the aircraft’s height would produce the reported ground-projected speed of 480 miles per hour. The six objects are best explained as a small flock of birds flying nearer to the aircraft than the crew assumed. More broadly, this work shows that even heavily redacted videos of unidentified anomalous phenomena can be analyzed using reproducible, quantitative methods to test specific hypotheses. Releasing the redacted sensor and platform data would provide information that could refute these hypotheses.

Keywords: Thermal infrared imaging, Airborne sensor video, Unidentified anomalous phenomena, Wingbeat frequency, Photometry, Parallax

Introduction

The U.S. Department of War has been releasing records of unidentified anomalous phenomena (UAP) under its PURSUE program (Presidential Unsealing and Reporting System for UAP Encounters), which includes dozens of videos from infrared cameras on military aircraft [1]. Redactions to the on-screen displays restrict the information these released videos carry, which makes many of these videos unresolvable simply due to lack of data. None of the sensor videos released under PURSUE provide the range from the sensor to the object, which limits how well the path of an object in a video can constrain its velocity [2]. Without knowing the range, a small object near the aircraft (such as a bird or balloon) can look the same as a large object farther away. Likewise, the aircraft’s own motion can make a slow object appear fast. For example, in the “Go Fast” video recorded by the U.S. Navy in 2015, an object that appeared to skim the sea at high speed was shown to be far above the sea and moving at about the speed of the wind, based on the pointing angles and range displayed by the sensor in unredacted video footage [3]. However, the data that were available to resolve the Go Fast case are redacted in the PURSUE sensor videos.

We found another example of this effect in one of the PURSUE videos from the Department of War’s sixth tranche of documents. DOW-UAP-PR135 was released on 18 September 2026 together with a mission report, DOW-UAP-D108, that had been filed by a U.S. Air Force crew for a sighting over the Middle East on 29 July 2025 [4, 5]. The report describes six small spherical objects, grouped together, that “seemed to be agile, frequently changing direction” and were “able to change directions quickly and simultaneously.” The report lists the estimated “kinetic velocity” as 480 mph (215 m/s) and the estimated altitude as flight level 220 (22,000 ft, or 6.7 km). The report also records no sensor engagement with the objects, which is consistent with the altitude value being an estimate rather than a measurement. In this analysis, we suggest that the six objects are a small flock of birds flying closer to the aircraft than assumed by the crew, with the apparent speed estimated at 480 mph most likely coming from the aircraft’s own ground-relative motion.

Birds can be recognized in video by their wingbeat. A flapping wing changes the projected surface area of the bird facing the camera, which modulates the bird’s brightness at the wingbeat frequency, or at twice that frequency. For birds in cruising flight, wingbeat frequencies range from about 2.5 Hz in the largest birds to more than 10 Hz in small songbirds [6–8]. The frequency of such a beat does not depend on the range, so it can be measured even when the range is unknown.

Here we perform a frame-by-frame analysis of the brightness and apparent size of each of the six objects in PR135. Every object beats steadily at 7.1–7.9 Hz, each independent of the others. Analysis of each beat eliminates video compression, pixel sampling, and sensor defects as explanations. We then apply the same frame-by-frame analysis to infrared video of flying animals from the ground-based camera array of the

Galileo Project near Las Vegas [9, 10] and find several examples of objects with beats at bird wingbeat frequencies. Finally, we show that a stationary or slowly moving object at 60–80% of the aircraft’s height is consistent with the reported speed estimate of the objects. Together, these results provide compelling evidence that the objects in DOW-UAP-PR135 are a small flock of birds. This analysis also underscores the value of beat-frequency analysis in the characterization of UAP, as the beat frequency does not depend on the range and can be applied even when sensor telemetry or aircraft altitude data are redacted.

Results

Beat frequencies of the six objects

The DOW-UAP-PR135 video shows six compact warm points that cross the field of view together from 0:05 to 0:10 and are then followed by the sensor until 0:47 (see Data). The objects move relative to one another by tens of pixels within 1–2 s, so that the group appears in turn as a line, a clump, pairs, and a loose ring. We tracked all six objects in every frame of the video from 41.3 to 46.3 s (Fig. 1; see Tracking the six objects).

Each object brightens and dims steadily throughout this interval (Fig. 2). The brightness of the objects beats at 7.11–7.85 Hz, with amplitudes of 12–26% about each running mean, and each beat stands 100–280 times above the median level of its spectrum. The same beat also appears in two measures of each object’s size: its pixel area and its fitted Gaussian width. For every object, these three peak frequencies agree within 0.13 Hz (Fig. 2).

The six objects do not beat together, and their frequencies span 0.74 Hz. A and C beat at 7.85 Hz, E and F at 7.60–7.64 Hz, B at 7.38 Hz and D at 7.11 Hz. Over the same frames, the brightness oscillations between any two objects are out of phase with each other. This phase difference between pairs ranges from 30° to 170° in magnitude, with eight pairs out of phase by more than 90°. Even A and C, which show the same beat frequency, are 119° apart. This eliminates video flicker as an explanation, as a beat produced by the video itself would reach all six objects at one frequency and in one phase.

Other control tests were also performed but were unable to produce such a beat (see Controls). Dots of constant brightness were planted in the video, moving at the same screen rate as the objects and encoded with the same settings as the video. These show normalized brightness amplitudes of only 0.6–1.7% in the 7.1–7.9 Hz band, compared to 12–26% for the objects. This eliminates the 7.49 Hz cadence of the video compression as an explanation for the beat frequency. These dots were also analyzed before encoding the modified video, to test whether the measurement aperture creates the beat frequency, but these show amplitudes of only 0.6–0.9% in the 7.1–7.9 Hz band. We also measured ten fixed defects of the sensor in the same way, which have their strongest peaks at 1.5–3.3 Hz.

The core of each object is clipped, meaning that its pixels reach the maximum recorded value (see Apparent size). A brighter object can thus also appear larger, so a beat frequency in a measurement of size does not necessarily imply a change in size.

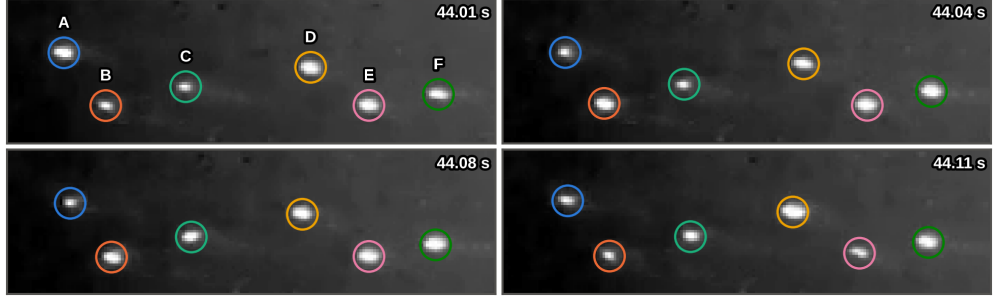


Fig. 1 Four consecutive frames of DOW-UAP-PR135 show the six objects (A–F) over about one beat (44.01–44.11 s).

This was tested by planting dots whose brightness beats but whose width is fixed; these show the same beat in pixel area, at 16–19%. If the clipped pixels are excluded from the fit, then the fitted width of the objects beats in step with their brightness (within 14°). When the same central region is excluded from the fit in every frame, so that the fitted pixels no longer depend on brightness, the width no longer beats in step with the brightness. The size measures therefore confirm the beat frequency by independent measurements, but they do not show a change in the objects’ size.

Beat frequencies of birds in infrared video

A steady beat of this kind could be produced by flapping wings. To see whether flying animals produce a beat frequency in thermal video, and at what frequencies, we applied the same frame-by-frame analysis to infrared video of the sky recorded by the Galileo Project [11] (see Infrared video of flying animals). We readily found numerous flying animals on evenings and mornings, all of which beat steadily in brightness and size together during the entire time on camera. The rows of Fig. 3 show examples of these beats on a common time scale, alongside their spectra.

These five flyers beat at 3.4–10.0 Hz, which falls within the observed wingbeat frequencies of birds in cruising flight (from about 2.5 Hz to more than 10 Hz [6–8]). The beat frequency can even provide constraints on the kinds of bird in a given observation, although this does not necessarily constrain particular species. Bats also beat their wings at about 3–14 Hz in free flight [12] and could explain some of these observations. This comparison shows that this frame-by-frame analysis method is able to recover a steady beat frequency from flying animals of size and brightness similar to the DOW-UAP-PR135 objects.

Parallax explains the reported speed

Birds do not fly at 480 mph. This suggests that the estimated speed in the video is an artifact of the parallax effect, or the apparent shift in an object’s position relative to a distant background when viewed from different positions. The report marks the speed as estimated and does not record that a laser range was taken (see Data). Without a range measurement, the only range the targeting system can assign to a point in the

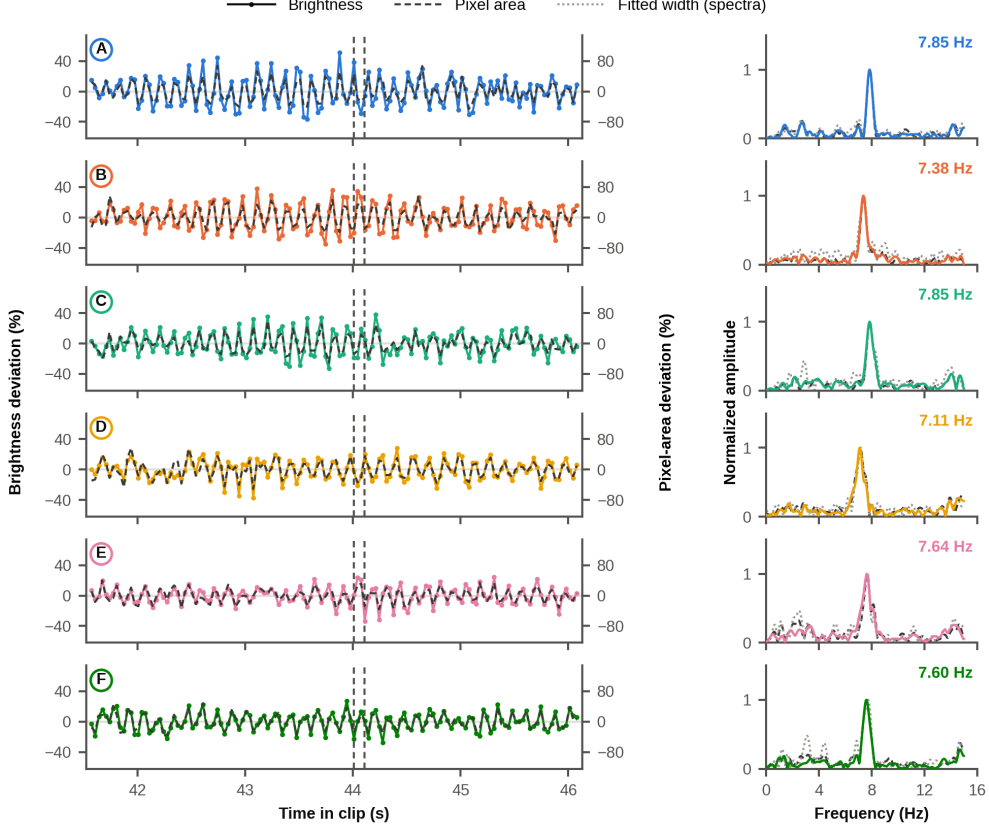


Fig. 2 Brightness and apparent size of the six objects beat at 7.1–7.9 Hz in the PURSUE video DOW-UAP-PR135. Left column: brightness (solid, left axis) and pixel area (dashed, right axis) of objects A–F, relative to 0.5 s running means; vertical lines mark the frames of Fig. 1. Right column: normalized amplitude spectra of brightness (solid), pixel area (dashed), and fitted width (dotted).

image is the range to where the line of sight meets the ground. This means that a speed estimated from the imagery is the speed of that ground point, not of the object itself.

Consider an aircraft at height h_{air} above the ground and an object at height h_{obj} on the same line of sight, with velocities v_{air} and v_{obj} taken as components along the aircraft’s ground track. The observed motion of the ground from the aircraft, v_{gnd} , compares to the motion of the object from the aircraft as $(v_{\text{gnd}} - v_{\text{air}})/h_{\text{air}} = (v_{\text{obj}} - v_{\text{air}})/(h_{\text{air}} - h_{\text{obj}})$. This gives the height of the object as

$$h_{\text{obj}} = h_{\text{air}} \left(1 - \frac{v_{\text{obj}} - v_{\text{air}}}{v_{\text{gnd}} - v_{\text{air}}} \right). \quad (1)$$

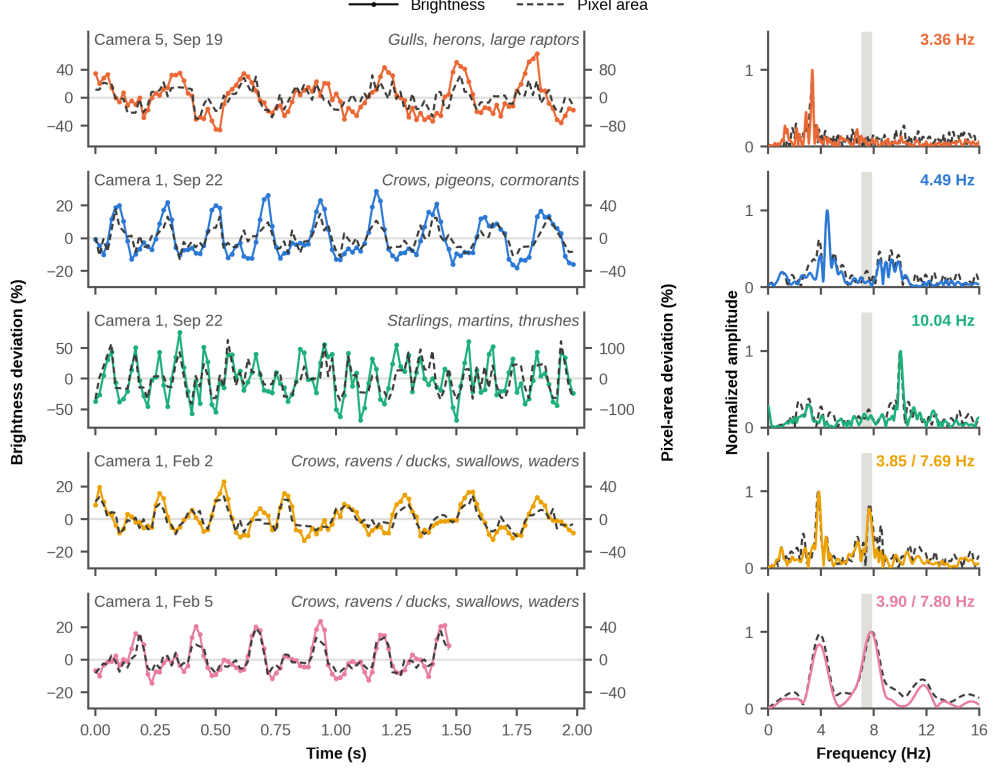


Fig. 3 Flying animals in infrared video beat in brightness and apparent size together in the Galileo Project data [11]. Left column: brightness (solid, left axis) and pixel area (dashed, right axis) of five flyers recorded by the Galileo Project, with the bird groups whose measured wingbeat frequencies match each flyer [8]. Right column: normalized amplitude spectra of brightness (solid) and pixel area (dashed). The last two flyers brighten twice per wingbeat. The gray band indicates the frequency range of objects A–F.

Even a stationary object ($v_{\text{obj}} = 0$) produces a non-zero ground-projected speed,

$$v_{\text{gnd}} = -\frac{h_{\text{obj}}}{h_{\text{air}} - h_{\text{obj}}} v_{\text{air}}, \quad (2)$$

which is directed opposite to the aircraft’s track. This is the parallax effect: as the aircraft approaches, the line of sight through the object tilts more steeply, and its intersection with the ground moves back toward the aircraft.

The imagery is consistent with parallax as an explanation. While the sensor follows the group (0:11–0:47), the burned-in north pointer shows the line of sight turning by only 2.7° , which implies that the aircraft was flying almost straight toward the objects. Earlier in the video (0:06–0:09), with the field of view fixed, the group crosses the screen at a uniform 212 pixels per second toward the bottom of the screen (see Group motion). For a camera looking down toward the northwest, the bottom of the screen lies to the southeast. The report gives the aircraft’s track as northwest and

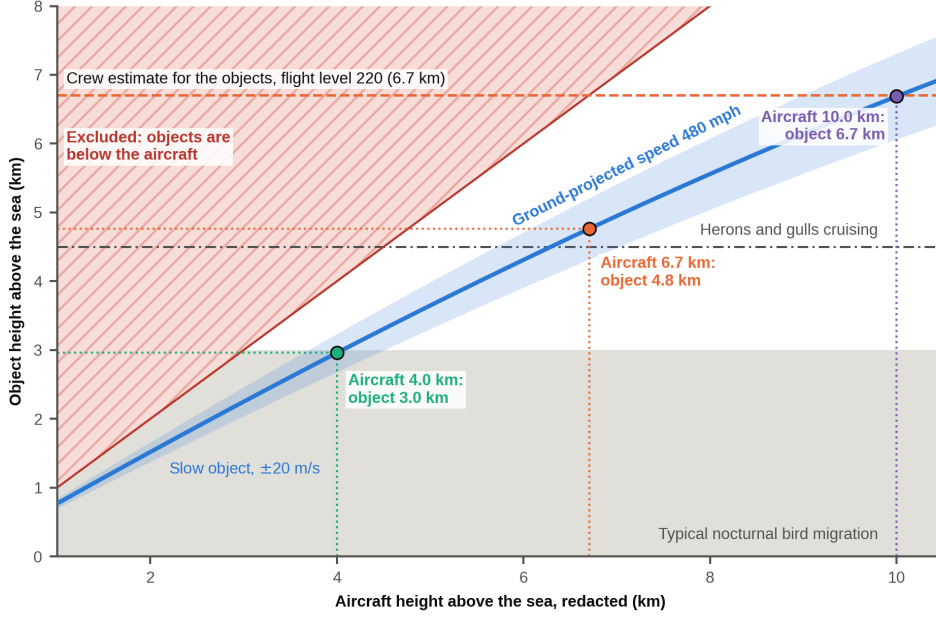


Fig. 4 A slow object near the aircraft reproduces the reported speed. Height of an object at which the ground-projected speed reads 480 mph, versus the aircraft’s height above the sea, which is redacted (equation (1)). The solid blue line indicates a stationary object, with shaded bands indicating object speeds of ± 20 m/s. Points mark three cases, with the aircraft at 4.0 km, at flight level 220 (6.7 km), and at 10.0 km. The hatched region, where the object would be above the aircraft, is excluded because the objects are seen against the sea. Altitudes are indicated for typical nocturnal bird migration [13] (gray band), herons and gulls cruising [14] (dash-dot line), and the flight level 220 estimate provided by the crew (dashed line).

the objects’ as southeast. Because the sensor then follows the group, any turn of the sensor moves all six objects together on the screen, so changes of direction that appear simultaneous do not require the objects to turn together.

Figure 4 shows the solutions of equation (1) at the reported value of 480 mph. The true airspeed, v_{air} , is calculated from the aircraft’s reported indicated airspeed of 120 knots, corrected for the air density at the aircraft’s height (equation (3)). A stationary object ($v_{\text{obj}} = 0$) gives a ground-projected speed of $v_{\text{gnd}} = 480$ mph when it is at 66–77% of the aircraft’s height above the ground. For example, an object at 3.0 km observed by an aircraft at 4.0 km would show a ground-projected speed of $v_{\text{gnd}} = 480$ mph. A slow-moving object (± 20 m/s) along the aircraft’s track widens this range to 60–84%. For a stationary object to be at the crew’s estimated flight level 220 (6.7 km), the aircraft would have to be about 10 km above the ground.

Discussion

Three results point to the same explanation. Each of the six objects beats steadily at 7.1–7.9 Hz, at its own frequency and phase, which neither the video nor the sensor produces. Flying animals recorded by infrared cameras beat in the same way, in

brightness and apparent size together, at 3.4–10.0 Hz. Finally, the reported speed and direction are what a slow object at 60–80% of the aircraft’s height would produce when no range is measured. The simplest explanation is a small flock of birds, nearer to the aircraft than the ground point on which the speed was estimated. The number of objects, their changing arrangement, and the report’s description of objects that were agile and changed direction are all consistent with this interpretation.

The frequencies of the six objects lie within the range measured for birds in cruising flight [6–8]. Of the 153 species measured by Bruderer et al. with tracking radar and cine camera, 12 have a median wingbeat frequency within 7.1–7.9 Hz in at least one flight condition. Among these are the northern shoveler, grey plover, bar-tailed godwit, turtle dove, common and pallid swifts, and several swallows and thrushes [8]. Birds also beat their wings faster in thinner air. Among nocturnal migrants tracked by radar, the wingbeat frequency rose by 0.4 Hz per kilometer of altitude in flap-gliding birds and by 1.1 Hz per kilometer in bounding birds [14]. This suggests that birds at 2–3 km could beat about 1–3 Hz faster than the same birds near sea level. The frequency alone therefore does not constrain a species. Six birds flying together would be expected to beat at similar but not identical rates and out of phase, as the six objects do.

The Galileo flyers also raise a question that the DOW-UAP-PR135 video alone cannot resolve. A bird’s wing can brighten the image once per wingbeat or twice (on the downstroke and the upstroke). Two flyers, both recorded on February mornings, show the second case (last two rows of Fig. 3). Their brightness rises twice in each cycle, strongly and then weakly, so their spectra have two peaks of similar height, near 3.9 Hz and near 7.7–7.8 Hz (right-hand panels). Birds like these put strong brightness power within the 7.7–7.8 Hz frequency band while beating their wings at about 3.9 Hz; this is a rate typical of crows and ravens [8]. In the DOW-UAP-PR135 objects, by contrast, the peak at half the beat frequency is only 10–17% of the main peak. Their brightness therefore does not show the unequal double pulse of the February flyers, and their beat is most likely the wingbeat itself, at 7.1–7.9 Hz. However, a double pulse of two equal brightenings would leave no peak at half the frequency and cannot be excluded, in which case the wingbeat of the DOW-UAP-PR135 objects would be 3.6–4.0 Hz. Both options fall within the range of birds.

The proposed location (see Data) also supports this interpretation. The birds most likely to be flying near Qaruh Island are seabirds: five species of tern breed on Kuwait’s offshore islands [15], and 5,000–6,000 terns nest on Kubbar, Umm al-Maradim, and Qaruh from May to July [16], so the observation, on 29 July, falls at the end of the nesting season. Terns, gulls, and cormorants beat their wings more slowly than the DOW-UAP-PR135 objects flicker. In cruising flight, the two terns measured by Bruderer et al. beat at 3.3 and 4.5 Hz, gulls at 2.7–3.8 Hz, and the great cormorant at 5.1 Hz [8]. An increase of 0.4 Hz per kilometer, as in flap-gliding birds [14], would leave the faster tern below 6 Hz even at 3 km. A double pulse of two nearly equal brightenings per wingbeat, at 3.6–4.0 Hz, would therefore fit a tern. Birds that beat at 6.6–8.5 Hz, including ducks, grebes, and waders such as plovers and godwits [8], would fit the direct reading. Tracking radar in southern Israel recorded large numbers of nocturnal migrants with the continuous wingbeats of waders and waterfowl [17]. The site thus allows both possibilities. Breeding common terns tracked by GPS stay

at their colonies for nearly all of the night, although birds from one marine colony flew slowly over the sea after dark [18], so a flock of terns at 23:22 local time, several hours after sunset, is possible but not typical.

The imagery also cannot exclude a fast object far from the aircraft. The parallax argument shows only that the reported speed does not require a fast-moving object, but the flicker (which does not depend on range) is the evidence that favors the bird hypothesis. A tumbling or rotating object could also flicker periodically; however, six such objects, moving together while each beats at its own steady rate of 7–8 Hz, are a less simple explanation than six birds. The redacted altitude of the aircraft would test the bird interpretation directly (Fig. 4).

Weather-radar profiles show nocturnal migration mostly within the lowest few kilometers, reaching only 1.5 km on some nights and above 3 km on others, at heights chosen largely for favorable winds [13]. In southern Israel, autumn migrants flew mainly below 1,500 m above sea level, where the trade winds favor southward flight, and those that continued into the day at high altitude were mainly herons and gulls [17]. Herons and gulls cruise at 4.5 km or more [14], and some songbirds climb above 6 km on migratory flights prolonged into the day [19]. For a stationary object to be within 3 km of the sea, the aircraft would have to be below about 4 km (3.7–4.5 km for object speeds of ± 20 m/s); for the object to be at 4.5 km, the aircraft would have to be at about 6.3 km. The crew’s altitude estimate was made without a range and is subject to the same ambiguity as the speed: an object seen along a line of sight can be at any height between the aircraft and the ground.

The reported altitude of the objects provides the greatest challenge to the bird hypothesis. The camera shows the group of objects crossing the field of view with the island and sea around it, with no horizon in view. This implies that the objects were seen against the sea surface and were therefore below the aircraft. The crew reported the objects at flight level 220; presumably the crew also knew their own altitude, suggesting that the aircraft was flying at an even higher altitude than flight level 220. If this is correct, then a slow object reading 480 mph would have been at about 4.8 km or higher (4.3–5.2 km for object speeds of ± 20 m/s, with the aircraft at 6.7 km; Fig. 4), which is above the heights of typical nocturnal migration and within reach only of high-flying birds such as herons and gulls. One possible explanation is that the speed or altitude estimates of the objects, or both, were incorrectly assessed or recorded by the crew. Knowing the altitude of the aircraft would resolve this uncertainty.

In general, a speed obtained from airborne imagery without a range describes the ground and not the object. For DOW-UAP-PR135, knowing the aircraft’s altitude, its track and ground speed over the clip, or the telemetry recorded with the video would turn the ground-projected speed into a constraint on the objects’ motion. But the brightness flicker test operates even when range is unknown and can be performed on the released pixels of any video in which an object is tracked for a few seconds. Other analyses of UAP could also search for steady beat frequencies as evidence of flapping flight. More complete sensor and platform data in future PURSUE releases would allow competing explanations to be tested more decisively.

This case shows the value of independent scientific investigation of UAP. Reports from the field are perceptual estimates, made in real time, during a mission, and often

without the information needed to interpret what was seen. Once recorded, such estimates can define a case as anomalous. This study involved researchers in academia working only from the released sensor videos, which led to a novel measurement technique that found a simpler explanation. Military assessment serves operational needs; scientific analysis, conducted in parallel, can test competing explanations transparently and resolve cases that would otherwise remain open. What limits such analysis is not the phenomena but the data.

Methods

Data

The video analyzed here is DOW-UAP-PR135, released by the U.S. Department of War in the sixth tranche of its PURSUE records on 18 September 2026 and hosted on the Defense Visual Information Distribution Service (DVIDS) as item 1023397 [1, 4]. The file is an H.264 (High profile) stream of 1280×720 pixels at 30000/1001 frames per second (29.97 Hz), 1798 frames (60.0 s), at an average bit rate of 2.93 Mb/s. We use the exact frame rate throughout this analysis, so frame n is at time $t = (n - 1)/29.97$ s. According to the accompanying video description [4], “several areas of contrast transit the sensor field-of-view” from 0:05 to 0:10, and the “sensor pans to track the areas of contrast, keeping them generally within the center of the frame” from 0:11 to 0:47. All of the measurements below come from these two intervals.

The accompanying mission report, DOW-UAP-D108 [5], was filed by the 65th Special Operations Squadron for a contact at 2022Z on 29 July 2025 in the Middle East. Every kinematic field describing the objects in the report is marked as estimated, including a “kinetic velocity” of 480 mph, a southeast trajectory, and an altitude of FL220. The report’s text reads “480MPH”, with a letter O; we interpret this as 480 mph, which is consistent with the official video description [4]; however, a speed of 48 mph (21 m/s) would itself be more typical of bird flight. The report does not record that the range to the objects was measured. It lists the aircraft’s own trajectory as northwest at 120 knots indicated airspeed, but the aircraft’s altitude is redacted.

The report’s location fields are redacted, but the first 10 s of the video show a small, low island carrying a lattice tower and a building. This closely resembles Qaruh Island, a small sandy island off the coast of Kuwait in the northern Persian Gulf (28.82°N, 48.78°E). We consider this a possible but unconfirmed identification of the site, from which we can speculate on the possible kinds of birds that are typically observed in the region. In local time (UTC+3), the contact time of 2022Z is 23:22, 4.7 h after sunset. The Moon was 25% illuminated and had set at 21:26 local time [20], so the sky was dark.

The aircraft type is also redacted. We infer that it was an MQ-9 Reaper, a remotely piloted aircraft, from three entries in the report. First, the 65th Special Operations Squadron operates the MQ-9 [21]. Second, a single aircraft flew for 20.6 h (takeoff 1734Z on 29 July, landing 1411Z on 30 July). Third, its speed of 120 knots is a normal MQ-9 cruise speed. This would indicate that the sensor video was taken while the crew operated the aircraft from a remote location. However, none of our results depends on the aircraft type. The ground-projected speed analysis (equation (1)) uses only the

aircraft’s reported speed and track, and assumes that no range measurement of the objects was taken.

Frame decoding and conventions

Every frame is decoded losslessly to an 8-bit image with FFmpeg and converted to a single luminance channel. We refer to the resulting pixel values as digital numbers (DN, 0–255). The infrared imagery is white-hot, so the objects appear as bright points. Positions are in pixels, with x to the right and y down. All rates are measured relative to the video frame, in screen coordinates; we explicitly state whenever we measure a rate relative to something else, such as the background or the ground. Redaction boxes (large regions of zero value) and the burned-in symbology are masked before any analysis.

Group motion

The screen rate of the group is measured over frames 185–284, while the camera holds a fixed field of view and the group crosses it. The group is found by an automatic moving-source search, linked frame to frame, and fit with a constant-velocity model. The azimuth of the line of sight is read in every frame from the burned-in north pointer, which the display draws at a fixed radius from the boresight reticle. We locate the pointer glyph by template matching and take its angle about the boresight. A turn of this pointer measures a change in the sensor’s azimuth.

Ground-projected speed

Equation (1) assumes flat ground at sea level, which holds over the Gulf, and heights that stay constant during the measurement. The aircraft’s true airspeed v_{air} is computed from its indicated airspeed, $v_{\text{IAS}} = 120$ knots (61.7 m/s), as a function of the unknown aircraft height h_{air} . An airspeed indicator responds to dynamic pressure, and the relationship can be obtained with the International Standard Atmosphere below 11 km,

$$v_{\text{air}} = \frac{v_{\text{IAS}}}{\sqrt{\sigma}}, \quad \sigma = \left(1 - \frac{L h_{\text{air}}}{T_0}\right)^{4.256}, \quad (3)$$

where σ is the air density relative to sea level, $T_0 = 288.15$ K is the sea-level temperature and $L = 0.0065$ K/m is the temperature lapse rate. For example, $v_{\text{air}} = 75.5$ m/s at $h_{\text{air}} = 4$ km. Instrument errors, compressibility (small at this speed), and wind are neglected. Equation (1) is then evaluated with v_{gnd} equal to the reported 480 mph, directed opposite to the aircraft’s track (Fig. 4).

Tracking the six objects

The six objects are resolved from one another and can be followed without a break from frame 1240 to frame 1389 (41.3–46.3 s). Before this interval, pairs of objects often merge, which makes them difficult to follow. In each frame, candidate sources are the local maxima (within 7×7 pixels) of a difference-of-Gaussians image (standard deviations of 1.5 and 5 pixels) that exceed 12 DN. Each candidate’s position is refined

to sub-pixel precision by the centroid of the positive response in a 5×5 box. The dark ringing that the display draws around each bright object is small, so it is not mistaken for a redaction box.

Tracking starts from frame 1330, where the six objects are well separated. They are lettered A–F from left to right in that frame. The tracker proceeds forward and backward from this frame. For each frame, the displacement common to the whole group (camera motion) is estimated, based on the offset that brings the most tracked objects within 3 pixels of a candidate, and then averaged over those matches. Each object’s position is predicted from this group shift plus its own recent velocity. Candidates are assigned to objects by minimum total distance [22], within a gate of 5 pixels, widened by 2 pixels for each consecutive frame in which an object is missed.

All six objects are detected in every frame of the interval. Their identities were checked by overlaying the tracks on the frames. Figure 1 shows the group in four consecutive frames (44.01–44.11 s, dashed lines in Fig. 2), spanning about one beat on one display scale, so that the rise and fall of each object’s brightness can be seen directly.

Photometry

The brightness of each object is the sum over a circular measurement aperture (i.e., a region of the image, not the camera’s optical aperture). This measurement aperture has a radius of 4 pixels and is centered on the object’s sub-pixel position, after subtracting the median of an annulus from 7 to 10 pixels. Pixels on the aperture’s edge are weighted by the fraction of their area inside the circle, computed on an 8×8 sub-pixel grid. The positions are smoothed with a 5-frame running mean first, so that the aperture does not follow centroid noise. A small aperture that is not weighted this way makes a moving point flicker by itself, as its image moves across the pixel grid. We found this effect with a 3×3 aperture, so we use a larger aperture with weighted edges.

Slow changes in brightness (from range, background, or gain) are removed by expressing the brightness $F(t)$ in the measurement aperture, at time t in the clip, as a fractional deviation from its 15-frame (0.50 s) running mean $\bar{F}(t)$: $\delta(t) = F(t)/\bar{F}(t) - 1$. This brightness deviation δ is plotted in Figs. 2 and 3. The first and last 7 frames are dropped from the running mean, which leaves frames 1247–1382 (136 frames, 4.54 s) for each object. The running mean follows slow changes in brightness (38–61% over the record) but absorbs only about 6% of a 7.5 Hz beat. Dividing instead by the mean of the whole record, with or without a straight-line trend removed, changes the measured beat frequencies by at most 0.03 Hz. A frame is flagged when another object lies within 9 pixels, which is the distance at which the two apertures overlap. This happens to B and C in 16% of frames.

Beat frequencies

We subtract the mean of each series $\delta(t)$ and multiply it by a raised-cosine taper that falls smoothly to zero at both ends [23], to limit leakage of power between frequencies. We then take its discrete Fourier transform $\hat{\delta}(f)$, zero-padded to 32 times its length so that the peak can be located finely. The amplitude spectrum is $2|\hat{\delta}(f)|/\sum_n w_n$, where

$w_n = \sin^2[\pi n/(N-1)]$ is the weight of the taper on the n -th of the N samples, so that a sinusoid of amplitude a gives a peak of height a . The beat frequency of an object is the highest peak between 1.5 and 14 Hz. The frequency resolution of a 4.54 s (136-frame) record is 29.97 frames per second / 136 frames = 0.22 Hz, and the sampling limit is 29.97 frames per second / 2 = 14.99 Hz. A beat at a true frequency f above the sampling limit would therefore appear at $29.97 - f$. Beats of different objects are compared through their cross-spectrum, with the phase at the peak giving the objects' relative timing.

Apparent size

The beat frequency is also calculated from two measures of each object's apparent size (Fig. 2). The first is the pixel area: the number of pixels within 7 pixels of the object that are more than 60 DN above the local background, taken as the median of the annulus from 9 to 11 pixels. The second is a fitted width: an elliptical Gaussian with a constant background, fitted to a 13×13 pixel stamp by least squares. The width is reported as the full width at half maximum, $2\sqrt{2 \ln 2} \sqrt{\sigma_x \sigma_y} \approx 2.355 \sqrt{\sigma_x \sigma_y}$, where σ_x and σ_y are the fitted standard deviations. Both series are detrended in the same way and analyzed exactly as the brightness.

The objects' cores are clipped at the top of the display range (that is, the brightness in the center exceeds the maximum recorded value). The brightest pixel reaches 255 DN in 82–100% of frames, with 4–6 pixels at that value. Clipped pixels carry no information about the true profile, so they are excluded from the fit. Clipping couples size to brightness. When the core is clipped, a brighter object can only show up as a larger clipped area. The pixel area indeed rises and falls in step with the brightness (Fig. 2). We therefore treat the size measures as independent estimates of the beat frequency, rather than a probe into the actual physical size of the objects.

Controls

We tested several instrumental effects that could produce a periodic flicker of a few hertz.

Video compression. The video stream is encoded with three bidirectional frames between reference frames; this means the frame types repeat every fourth frame, which gives a cadence of 29.97 frames per second / 4 frames = 7.49 Hz, close to the observed beats. We planted six dots of constant brightness over a frame in the video, moving at the same screen rates as the objects, and added the clip's own temporal noise. We encoded these modified clips with the same settings as the original video clip (H.264 High profile, a keyframe every 60 frames, 3 bidirectional frames, 2.9 Mb/s), decoded them, and measured them using the same method as with the objects.

Pixel phase. The same planted dots were measured before encoding, to test whether the measurement aperture alone causes a moving point to flicker (see Photometry).

Common cadence. Any flicker made by the video itself (such as dropped or repeated frames, compression, or automatic gain) would affect every object at the same frequency and in the same phase. We therefore compared the frequencies of the objects and their cross-spectral phases over the same frames.

Sensor defects. Ten fixed bright pixels of the sensor (defects that stay in one place on the screen) were tracked and measured using the same method as with the objects.

Size or brightness. The effect of size and brightness was tested with further sets of planted dots that are matched to the objects and encoded in the same way. The first set was constructed with brightness beats of $\pm 20\%$ at 7.0, 7.5 and 7.9 Hz while the width is fixed: a size measure that beats on these dots is following brightness, not size. The second set was constructed with width beats of $\pm 10\%$ at the same frequencies while the peak is fixed: a size measure that misses these dots could not detect a real change in size. Finally, the Gaussian fit to the real objects was repeated with a fixed central disk (radius 2.5 or 3 pixels) excluded in every frame, in addition to the clipped pixels, so that the fitted region no longer grows with brightness.

Infrared video of flying animals

We applied the frame-by-frame analysis method to video from an all-sky infrared camera array of the Galileo Project (a Dalek) at the project’s Hideout site near Las Vegas, Nevada [11]. The Dalek holds eight uncooled FLIR Boson 640 cameras that observe at infrared wavelengths (7.5–13.5 μm) [10, 11]. Each has a $50^\circ \times 40^\circ$ field of view (about 1.4 mrad per pixel) centered 30° above the horizon. The files are 8-bit, compressed with H.265, and recorded at 60 frames per second. The sampling limit is therefore 30 Hz, twice that of DOW-UAP-PR135. The cameras record only in daylight, so we used the first and last hours of recording, when birds are most active.

The five flyers in Fig. 3 were recorded by cameras 1 and 5 on the evenings of 19 and 22 September 2026 (17:20–18:47 local time) and on the mornings of 2 and 5 February 2026 (07:14–07:15 local time). Moving objects were found by subtracting a running average of the scene and linked into tracks. Each track was then measured exactly as the DOW-UAP-PR135 objects were (see Photometry and Beat frequencies), with the 0.5 s running mean spanning 30 frames. The beat frequencies from brightness and pixel area agree within 0.1 Hz for each flyer, and each record lasts 1.5–14.9 s. As a control, the same measurement aperture was placed 15 pixels to either side of each track, on empty sky, where it shows 4–28% of the flyer’s amplitude at the flyer’s frequency. A point of constant brightness moving across the pixel grid at each flyer’s rate, measured in the same way, flickers by at most 2.0% at unrelated frequencies, compared to 7–28% for the flyers (see Photometry).

The analysis code, the figures, and drafts of the text were developed with Claude Opus (Anthropic), a large language model.

Data availability. The video DOW-UAP-PR135 and the mission report DOW-UAP-D108 are public releases of the U.S. Department of War [1, 4, 5]. The infrared footage of flying animals was provided by the Galileo Project [10, 11]. Short clips of the five flyers in Fig. 3 were cut from the original files without re-encoding and are archived on Zenodo (<https://doi.org/10.5281/zenodo.23021686>), together with unmodified copies of the PR135 video file and the D108 report. The archive also includes scripts for reproducing all measurements and figures in this analysis.

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