

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ARASHI VISION (U.S.) LLC (D/B/A INSTA360),
Petitioner,

v.

GOPRO, INC.,
Patent Owner.

Case No. IPR2024-01164
U.S. Patent No. 10,958,840

PATENT OWNER'S RESPONSE

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EXHIBIT LIST

No.	Exhibit
2001	Declaration of Hassan Foroosh, Ph.D.
2002	<i>Curriculum vitae</i> of Hassan Foroosh, Ph.D.
2003	“GoPro Celebrates Surpassing 50 Million Cameras Sold,” produced as GOPRO_00063291 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2004	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - [REDACTED] in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2005	“NHL, NHLPA Partner with GoPro To Deliver Hockey Fans Unique Perspectives Of The Game,” produced as GOPRO_00063270 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2006	Complaint, <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2007	E-mail from Alex S. Yap on October 9, 2024
2008	“GoPro Named Exclusive Action Camera of Red Bull Rampage, the World’s Biggest Freeride Mountain Bike Event,” produced as GOPRO_00063323 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2009	“GoPro and Adobe Collaborate to Bring Unique Content to Adobe Stock Users,” produced as GOPRO_00063341 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2010	“73 rd Annual Technology & Engineering Emmys,” produced as GOPRO_00000009 in <i>In the Matter of Certain Cameras,</i>

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	<i>Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2011	“Believe the Hype: GoPro Showcases Award-Winning HERO7 Cameras at CES 2019,” produced as GOPRO_00063251 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2012	“GoPro Wins Second Emmy® Award for Groundbreaking Digital Imaging Technology,” produced as GOPRO_00063339 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2013	“J.P. Morgan – North America Equity Research (21 September 2018),” produced as GOPRO_00359592 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2014	“GoPro Hero 9 Black vs Hero 8 Black: 9 key differences you need to know,” produced as GOPRO_00010039 in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2015	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER [REDACTED] in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2016	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] served in <i>In the Matter of Certain Cameras, Camera Systems, and Accessories Used Therewith</i> , Inv. No. 337-TA-1400
2017	Declaration of Patrick T. Schmidt in Support of Patent Owner's Motion for <i>Pro Hac Vice</i> Admission (March 14, 2025)
2018	Supplemental Declaration of Hassan Foroosh, Ph.D.

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2019	U.S. provisional patent application Ser. No. 61/407,630 filed on Oct. 28, 2010 (“Kwatra provisional application”)
2020	Transcript of April 4, 2025, Deposition of Petitioner’s Expert Dr. Katsaggelos
2021	Excerpt of ITC Trial Transcript including Testimony of Petitioner’s Expert Mr. Goodin
2022	Screenshot of Dr. Katsaggelos lecture on Coursera
2023	U.S. Patent 10,027,893 (“Bell”)
2024	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - Declaration of Pablo Lema
2025	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER [REDACTED]
2026	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - [REDACTED]
2027	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED]
2028	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED]
2029	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED]
2030	User Manuel for GoPro HERO7 Black (CX-0522)
2031	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED]

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2032	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2033	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2034	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2035	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2036	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2037	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2038	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2039	CONFIDENTIAL BUSINESS INFORMATION – SOURCE CODE - SUBJECT TO PROTECTIVE ORDER [REDACTED] [REDACTED]
2040	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER – [REDACTED] [REDACTED]
2041	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER – [REDACTED] [REDACTED]
2042	Technical Review of HERO8 Black (CX-1388)

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2043	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - [REDACTED]
2044	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - [REDACTED]
2045	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - [REDACTED]
2046	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER - [REDACTED]
2047	CONFIDENTIAL BUSINESS INFORMATION SUBJECT TO PROTECTIVE ORDER [REDACTED]
2048	Insta360 Speeds Up Workflow with New 360 Reframing Tool, Better Stabilization & Quick Reader (CX-0077)

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VI. INTRODUCTION

GoPro is an industry leader in developing innovative video stabilization technologies. Its Emmy Award-winning HyperSmooth technology brought a step-change improvement to digital video stabilization, enabling professional-quality footage in dynamic environments. The challenged claims reflect these innovations and should be upheld.

Arashi Vision (U.S.) LLC (d/b/a Insta360) (“Petitioner”) challenges independent claims 1 and 16 and dependent claims 2-15 and 17-21 of U.S. Patent No. 10,958,840 (Ex. 1001, “the ’840 patent”) on seven grounds, each relying primarily on Bell (Ex. 1006) and Shi (Ex. 1007).¹

Shi Fails to Disclose the “Low-Light High-Pass Parameter” of Claim 1

Petitioner relies on a “coefficient” based on a “motion blur kernel” in Shi. The Board identified the issue of “whether Shi discloses a ***low-light high-pass parameter***.” Based on preliminary arguments, the Board understood that a “low-light high-pass parameter” is “a parameter that controls the amount or strength of smoothing used in motion blur compensation.” (I.D. at 8-9).

¹ Ground 5 (claim 13) adds Kwatra (Ex. 1012).

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While the Board correctly noted that a low-light high-pass parameter controls the amount or strength of smoothing used in motion blur compensation, the terms “low-light” and “high-pass” must also be given meaning.

Specifically, GoPro's parameter is based on “low-light” conditions indicated by longer exposure times. The “low-light” term is not superfluous. Petitioner's expert admitted that blur can be caused by “many different reasons,” low-light conditions being just one. *See* Ex. 2020 at 103:22-104:8. GoPro's claimed approach targets blur caused by low-light conditions, while otherwise prioritizing smoothing strength.

GoPro's parameter also enables a “high-pass” system—one that allows more **high** frequencies to **pass** through while attenuating lower frequencies. Petitioner's expert Dr. Katsaggelos testified that a “high-pass system” is “one that allows most of the information of the signal at high frequencies to go through while attenuating the information at the low frequency of the signal.” *Id.* at 94:6-15. Further, when teaching students, Dr. Katsaggelos describes “high-pass” systems as those that “allow the high frequencies to go through the system unchanged.” Ex. 2022.

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Accordingly, a “low-light high-pass parameter” is “a parameter that controls the amount or strength of smoothing used in motion blur compensation by allowing more high frequencies to pass through based on low-light conditions.” This construction gives meaning to the terms “low-light” and “high-pass.”

Shi does not disclose any such parameter. Instead, Shi first applies a “low-pass” filter for smoothing that *removes* high frequencies. It then calculates a motion blur kernel to estimate the amount of blur, irrespective of lighting conditions, by comparing projection matrices at the start and end of the exposure period and analyzing motion within the frame. Ex. 1007, 18:1-26. Critically, Shi’s approach is triggered by total *estimated blur*—not specifically by low-light conditions. *Id.* at 18:7-26.

Shi’s motion blur kernel is used to calculate a coefficient governing the degree to which the smoothed trajectory is blended with the original. *Id.* at 18:27-40. Shi reintroduces components of the original motion, without regard to frequency, and mixes them with the smoothed trajectory. *Id.* at 18:1-5. Thus, Shi is not a “*high-pass*” approach. It attenuates smoothing strength across the entire frequency range.

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The different techniques have real-world implications. GoPro's cameras are designed for sports like cycling or running, where camera shake is a major issue and smoothing takes priority over blur correction. GoPro's invention reflects the insight to specifically target blur from low-light conditions, while maintaining smoothing strength otherwise.

Shi, by contrast, addresses a smartphone solution where blur is prioritized over camera shake. It reduces smoothing strength generally, without regard to cause. That is why Shi nowhere mentions low-light conditions and does not operate as a high-pass system. It estimates total blur and applies an across-the-board smoothing reduction.

Accordingly, Shi's "coefficient based on the motion blur kernel" is not a "low-light high-pass parameter" as required by the claims.

Kwatra Fails to Disclose the "Weight-Balance Parameter" of Claim 13

For Ground 5 only, Petitioner contends that Kwatra discloses the required "weight-balance parameter" that "controls types of motion that are minimized in smoothed trajectory generation, the types of motion including rotational velocity and rotational acceleration."

As in IPR2024-01186, Petitioner relies exclusively on ***linear motion models*** in Kwatra (Ex. 1012). In instituting the -01186 proceeding, the Board

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recognized a disputed fact issue regarding whether Kwatra teaches or suggests minimizing *rotational* velocity and acceleration.

Kwatra does not teach or suggest minimizing rotational velocity and acceleration. In fact, Kwatra's own inventors explicitly rejected non-linear (rotational) optimizations in favor of simpler linear methods due to computational complexity (as "not fast enough for real-time performance").

Kwatra's motion estimation and optimization process depends upon two-dimensional, linear motion models of trackable features extracted from image data. While some models include a rotational degree of freedom, Kwatra expressly avoids applying its smoothing constraints directly to rotational parameters to avoid non-linear computations. Ex. 1012 at 17:5-22. Kwatra accepts that "rotation and scale may not remain smooth" and instead applies bounding constraints to ensure scale and rotation "do not deviate too much." *Id.* at 17:18-49.

Critically, Petitioner fails to account for these disclosures. As Dr. Foroosh explains, they establish that Kwatra fails to render the '840 patent's weight-balance parameter obvious. Applying boundary constraints on feature rotation is not analogous to using a weight-balance parameter to control minimization of rotational velocity and acceleration.

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Petitioner also fails to address how Kwatra's "feature tracking" approach is inherently two-dimensional—at most considering a single rotational degree of freedom within the image plane. It does not model 3D rotation of the camera housing. Petitioner does not explain how a POSITA would combine Kwatra's 2D optimization with Bell and Shi's 3D trajectory modeling using gyroscopes and accelerometers. Kwatra's techniques are fundamentally incompatible with the 3D stabilization logic of Bell and Shi, and a POSITA would not have had a reasonable expectation of success in combining them.

Moreover, whereas Bell and Shi address computationally constrained mobile devices, Kwatra's approach is computationally demanding and designed for offline, server-based processing.

Objective Evidence of Non-Obviousness

Finally, secondary considerations—including commercial success, widespread industry recognition and awards for HyperSmooth, and copying by competitors—further support non-obviousness. The '840 patent innovations delivered real-world advantages not achieved by prior art, reinforcing the patentability of the challenged claims.

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VII. OVERVIEW OF THE '840 PATENT

The '840 patent, titled “Systems and Methods for Stabilizing Videos,” discloses an advanced system designed to stabilize video content under varied conditions. The system measures rotational positions of the image capture device to generate a “trajectory of the image capture device during the capture duration.” Ex. 1001, 1:18-29; 30:18-23 (claim 1); 32:28-33 (claim 16). The claims then articulate a novel approach to determining a “smoothed” trajectory of the camera housing from this measured trajectory. Ex. 2018, ¶ 44.

Among the '840 patent's key innovations is the introduction of tunable parameters allowing the system to adaptively modulate stabilization based on environmental conditions and/or the characteristics of the captured motion. Ex. 1001, 21:17-25; Ex. 2018, ¶ 45. These tunable parameters include the “low-light high-pass parameter” (*id.*, 21:59-22:21), “weight-balance parameter” (Ex. 1001, 17:32-60, 21:17-58), and “stickiness parameter” (*id.*, 22:22-41).

Low-light high-pass parameter

The low-light high-pass parameter addresses the challenge of stabilizing videos captured in low-light environments by controlling the extent

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to which the system compensates for motion blur occurring during frame exposure. Ex. 1001, 21:59-22:21; Ex. 2018, ¶ 46.

A central concern addressed by the patent is how to stabilize video in low-light environments, where longer exposure times increase the likelihood of motion blur. Ex. 2018, ¶ 47. The specification describes how camera motion during the exposure period—termed “intra-frame” motion—can become “encrusted” in the video frame, leading to undesirable blur artifacts. *Id.* at 18:1–24; 21:66-22:7. Strong smoothing in this situation creates what the patent calls a “poor visual impression.” *Id.* at 22:2–5. The goal of the invention, therefore, is to stabilize in a way where “intra-frame motion is taken into account so that the smoothed trajectory is smooth for inter-frame phases while corresponding to the original motion for intra-frame phases.” *Id.* at 18:18-20; Ex. 2018, ¶ 47.

Thus, the specification describes modifying the smoothing strength based on exposure time and other factors such as motion of the image capture device. Ex. 1001 at 18:25–46; Ex. 2018, ¶ 48. For example, in some implementations, a certain portion of “*high frequencies in the input may be kept based on the image capture configuration, such as exposure start time*

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and exposure duration time” to compensate for “*motion blur and/or lowlight image capture conditions*.” *Id.* at 17:61–18:9.

Figure 7 and its accompanying discussion elaborate on this by illustrating how smoothing strength values (S1, S2, S3, S4) can be modulated depending on exposure time and frequency of motion within the frame. *Id.* at 18:43-19:59. In particular, “*longer exposure time may be used with low light conditions,*” “*may result in greater amount of motion blur,*” and thus require a reduction in smoothing strength. *Id.* at 19:18-21; 19:25–26. Additionally, intra-frame motion exceeding a “high motion threshold” is considered high-frequency motion, which further impacts smoothing. *Id.* at 18:64-19:2; Ex. 2018, ¶ 49.

Within this context of adaptive smoothing in low-light conditions, the specification introduces the claimed “low-light high-pass parameter” as a parameter that “controls the amount/strength of smoothing performed to generate the smoothed trajectory.” Ex. 1001 at 21:59-61; Ex. 2018, ¶ 50. The specification reiterates the distinction between “inter-frame motion,” which is smoothed subject only to a margin constraint, and “intra-frame motion” which is addressed by a higher value of the low-light high-pass parameter to let the smoothed trajectory follow the observed trajectory more closely. *Id.* at

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21:61-22:21. Reduction in smoothing strength is done in a “high-pass” manner—preserving more high-frequency motion while continuing to attenuate low-frequency motion. *Id.* at 22:8–25. (“[T]he output motion may include high frequencies that mask motion blur within the visual content.”).

Thus, as described in the specification, the low-light high-pass parameter targets a specific issue—stabilizing video captured in low-light conditions, where longer exposure durations create intra-frame blur. Ex. 2018, ¶ 51. It modifies smoothing strength in a “high-pass” manner that preserves high-frequency motion, thereby reducing the appearance of blur, while maintaining stabilization strength for low-frequency motion. *Id.*

The result is a more natural and visually pleasing video output for GoPro’s use cases. *Id.*, ¶ 52. As used in the claims, the “low-light high-pass parameter” is therefore best understood as “a parameter that controls the amount or strength of smoothing used in motion blur compensation by allowing more high frequencies to pass through based on low-light conditions.” *Id.*

Weight-balance parameter

The weight-balance parameter provides a mechanism for stabilizing video by determining how much emphasis to place on minimizing rotational

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velocity versus rotational acceleration. Ex. 1001, 17:32-60, 21:17-58; Ex. 2018, ¶ 53. This allows the system to adapt to different types of motion and produce smoother, more natural video. *Id.*

Rotational Motion of the Camera Housing

Rotational motion is typically described using yaw, pitch, and roll angles (“Euler angles”), which represent rotation around three perpendicular axes:

- **Yaw**— Rotation around the **vertical axis** (turning left or right).
- **Pitch**— Rotation around the **lateral axis** (tilting up or down).
- **Roll**— Rotation around the **longitudinal axis** (tilting side to side).

Ex. 2018, ¶ 54.

While the claims do not explicitly reference **yaw**, **pitch**, or **roll**, minimizing rotational velocity and acceleration of a camera housing—a three-dimensional object in space—necessarily involves at least one of these angles. *Id.*, 55.

Minimizing a Combination of Rotational Velocity and Acceleration of the Camera Housing

The '840 patent improves video stability by determining a smoothed trajectory that minimizes a controllable combination of rotational velocity and rotational acceleration of the camera housing. *Id.* ¶ 56.

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The specification explains that “the smoothed trajectory may be determined based on minimization of a rotational velocity . . . and a rotational acceleration of the image capture device . . . while respecting a set of constraints.” *Id.* at 17:32–37. For example, a “smooth path” of yaw, pitch, or roll angle may be generated by “finding a path of the image capture device . . . that minimizes a combination of a time derivative, a second time derivative, and/or other time derivative(s)” of these angles. *Id.* at 17:37–53. By minimizing rotational velocity and acceleration of the camera housing, the ’840 patent accounts for the real-world motion of a camera rotating in the 3D space, ensuring smoother video output. *Id.* ¶¶ 56-59.

This optimization inherently involves non-linear and trigonometric relationships. In the preferred embodiment, a cost function applies weighting factors to different rotational motion derivatives to balance stabilization performance. *Id.* Equation 54 (*id.* at 11:2-22) minimizes both the first and second time derivatives of a function expressed in terms of rotational angle (θ)—which correspond to rotational velocity and rotational acceleration of the housing (*id.*, ¶ 57):

$$\min \left(\left\| \frac{d}{dt} \theta \right\|^2 + \left\| \frac{d^2}{dt^2} \theta \right\|^2 + \dots \right)$$

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The specific combination that is minimized is set by the weight-balance parameter, which “may range between 0 and 1, with 0 corresponding to minimization of angular velocity and 1 corresponding to minimization of angular acceleration.” *Id.* at 21:36–39; Ex. 2018, ¶ 60. Intermediate values allow the system to minimize both types of motion, “with minimization of different types of motion weighed according to the value.” *Id.* at 21:39-42.

The patent explains the practical effect of different values:

- Minimizing **only angular velocity** (value = 0) may lead to trajectories with sharp, piecewise-linear corners that, as the patent explains, “prefer[] to keep a steady position when possible” and “minimize apparent motion between video frames”—but the resulting motion “may appear unnatural.” *Id.* at 21:44–50.
- Minimizing **only angular acceleration** (value = 1) may reduce corner points and result in smoother acceleration, but it “may produce more motion than [s]ole minimization of angular velocity.” *Id.* at 21:50–54.
- Minimizing **a combination** (value between 0 and 1) produces a trajectory that blends these two effects, with weights determined by the parameter value. *Id.* at 17:54–58.

In this way, the weight-balance parameter gives the system the ability to fine-tune the optimization, enabling more natural and visually appealing video. Ex. 2018, ¶ 61.

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Stickiness parameter

The stickiness parameter “control[s] the extent by which preceding portion(s) of the (observed) trajectory impacts determination of the smoothed trajectory.” Ex. 1001, 22:22–25. The parameter may range between 0 and 1—where 1 results in a “lazy” stabilizer that “maximizes the impact of the preceding motion/position,” and 0 results in the smoothed trajectory being generated without taking the preceding motion into account. *Id.*, 22:25–33. Values between 0 and 1 provide flexible weighting of the preceding motion’s influence, allowing for a dynamic balance between responsiveness and stability. Ex. 2018, ¶ 62.

Together, these parameters reflect a sophisticated, configurable approach to digital video stabilization—capable of adapting to varied motion types and lighting conditions. Ex. 2018, ¶ 63.

Temporal horizon enabling approximation of intentional motion

Unlike conventional approaches that distinguish between stationary and moving cameras to infer jitter, the ’840 patent’s “***temporal horizon enabling approximation of intentional motion***” leverages a duration of future motion to estimate user intent at a given moment, regardless of whether the camera is stationary or moving. *Id.*, ¶ 64.

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The specification explains that “intentional motion may include a forward motion to follow an object of interest, a panning motion to shoot a wide view of a scenery, and/or other motion,” while “unintentional motion may result in noise . . . caused by shaking hands, vibrations, bumps.” Ex. 1001, 9:8-16. To distinguish between these types of motion, the patent teaches that “intentional motion may be characterized by lower frequency motion than unintentional motion,” and that “a sufficiently long temporal horizon of experienced motion may need to be used” to identify it. *Id.*, 9:17-23; Ex. 2018, ¶ 65.

The specification explains that “positions/motions of the image capture device in the ‘future’ may be analyzed (look ahead) to determine whether particular position(s)/motion(s) of the image capture device at a moment is an intended motion or an unintended motion.” Ex. 1001, 15:1-6; Ex. 2018, ¶ 66.

Figure 5C illustrates how the temporal horizon enables approximation of whether a given movement is intentional—regardless of the camera’s state (e.g., stationary or moving) (Ex. 2018, ¶ 67):

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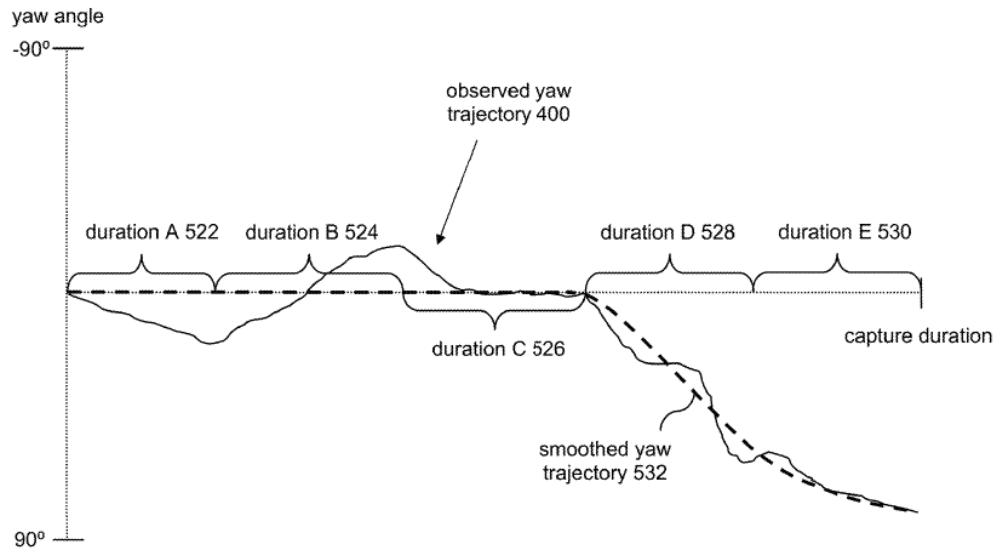


FIG. 5C

In processing durations A, B, and C, the system's ability to look-ahead across a sufficiently long temporal horizon of the observed trajectory (400) allows it to infer that measured motion within these durations was unintentional and process the smoothed trajectory (532) accordingly. *Id.*, ¶ 68. In processing duration D, by contrast, the system understands that detected motion persists into the future and is therefore intentional. *Id.* Thus, the system can immediately begin processing a trajectory at the beginning of duration D that smoothly tracks intended motion. *Id.* The description in the specification is instructive:

Based on the subsequent portion(s) (look ahead) of the observed yaw trajectory 400, the smoothed trajectory component 104 may determine that the staggered rotation of the

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image capture device to the right during durations 528, 530 included unintended motions (non-continuous rotation to the right), and may determine the smoothed yaw trajectory 532 to include continuous rotation to the right during durations 528, 530.

Thus, the “temporal horizon *enabling approximation of intentional motion*” requires inferring intentional versus unintentional motion in a specific manner. Ex. 2018, ¶ 69. The claim requires more than simply comparing detected motion in a current frame to a motion threshold, or comparing the difference between two successive frames. *Id.* It requires looking ahead over a temporal horizon sufficiently long to approximate intentional motion in producing the smoothed trajectory. *Id.*

These innovations are integral to HyperSmooth, which played a significant role in the commercial success and industry recognition of GoPro's cameras. *Id.*, ¶ 70.

VIII. OVERVIEW OF CERTAIN CITED ART

The petition challenges claims 1 to 21 of the '840 patent on seven grounds. Ground 1 asserts that Bell and Shi render independent claims 1 and 16, and certain dependent claims, obvious. Grounds 2-7 address the remaining dependent claims by combining Bell and Shi with additional references.

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Ground 5 asserts that Bell, Shi, and Kwatra render claim 13 obvious. Below are short summaries of the primary references.

A. Ground 1 Cited Art

1. Bell (Ex. 1006)

Bell discloses a video stabilization system that uses gyroscopes to measure device motion and applies a virtual camera model. Ex. 1006, 1:15-29; 6:9-18; 8:51-56; Ex. 2018, ¶ 72-75.

It is undisputed, however, that Bell fails to disclose key features of the '840 patent—such as the low-light high-pass parameter to reduce smoothing in low-light conditions; the weight-balance parameter to minimize a combination of rotational velocity and acceleration; or the stickiness parameter to flexibly control prior motion influence. Ex. 1001, 17:40-53; 21:17-58; 22:22-41.

Bell is closely related to the Bell Paper (Ex. 1004). The Petition notes that “Bell and Bell Paper have the same inventors or authors and are directed to similar subjects,” and that “[a] POSITA consulting Bell would have been motivated to turn to Bell’s related publication, Bell Paper . . .” Petition at 68. The Bell Paper discourages using acceleration data in stabilization, calling it “difficult and of limited value.” Ex. 1004 at 4.

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These distinctions make Bell materially different from the '840 patent.
Ex. 2018, ¶ 75.

2. Shi (Ex. 1007)

Shi discloses a stabilization method for smartphones, using a hybrid of optical and electronic image stabilization (OIS/EIS). Ex. 1007 at 1:5-15; 1:36-37; Ex. 2018, ¶¶ 76-80. “[B]y using OIS lens shift positions, the [EIS] stabilization processing can correct for distortion caused by the OIS systems . . .” *Id.* at 1:40-42. Shi’s smoothing method involves a Gaussian “low-pass” filter that *removes* high-frequencies—regardless of lighting conditions. *Id.* at 12:54-57; 16:66-17:2. Only *after* smoothing does Shi estimate motion blur during an optional, third transformation ($V_2(T)$). *Id.* at 17:53-56. Shi estimates blur by comparing projection matrices at the start and end of exposure. *Id.* at 3:19-24; 18:1-26. The blur kernel is then used to calculate a coefficient governing how much smoothed trajectory is blended with the original trajectory. *Id.* at 18:27-40. Spherical linear interpolation (Slerp), weighted by this coefficient, reintroduces components of the original motion, regardless of frequency. *Id.* at 18:1-6; 18:30-33.

Shi’s blur correction is triggered by the amount of blur—not by low-light conditions. Ex. 2018, ¶ 80. Shi never mentions lighting at all. Nor does

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Shi implement a “high-pass” system: it blends original and smoothed trajectories, rather than allowing high-frequency motion to pass through. *Id.*

3. Kwatra (Ex. 1012)

Kwatra discloses a method estimating camera motion by tracking image features across frames and fitting ***linear motion models*** to the detected feature motion. Ex. 1012, 13:23-14:52. A smoothed camera path is obtained by minimizing derivatives of these linear segments. *Id.*, 1:48-57, 2:6-14, 6:1-28, 6:40-42, 13:23-48.

Kwatra's Camera Path Model Uses Linear Motion Fitting

Kwatra models an “original camera path” (“C(t)”) using tracked image features and fits linear motion between frames. Ex. 1012, 5:41-53, 12:11-37, 19:39-58, claim 6; Ex. 2018, ¶¶ 81-91.

It then conceptualizes a “smooth” camera path (“P(t)”) by applying a linear transformation B(t), Ex. 1012 at 13:49-56:

$$P(t)=C(t)*B(t)$$

The smoothing involves solving for B(t) per segment—resulting in a static, constant velocity, or constant acceleration path. *Id.* at 13:23-49.

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Kwatra's Cost Function Minimizes Only Derivatives of a Linear Path Representation

Kwatra's cost function (Equation 7) minimizes first, second, and third derivatives of the linear path:

$$a \left| \frac{dP}{dt} \right| + b \left| \frac{d^2 P}{dt^2} \right| + c \left| \frac{d^3 P}{dt^3} \right|$$

where a , b , c are weights. *Id.* at 13:62-14:12. "Equation (7) can be minimized by setting each derivative equal to zero . . ." *Id.* at 14:8-12; Ex. 2018, ¶ 88.

Kwatra Intentionally Avoided Non-Linear Minimization

Kwatra deliberately avoids non-linear optimization, citing computational constraints. Ex. 2018, ¶¶ 89-90. Kwatra's inventors expressly rejected non-linear smoothing because it was "not fast enough for real-time performance." Ex. 2019, provisional application (incorporated by reference in Kwatra):

- "[C]oncatenation of parameters is not linear anymore, requiring a more complex non-linear optimization method which is not fast enough for real-time performance. We therefore opt for a simpler linear update scheme . . ." (*Id.* at 3).
- "Since imposing smoothness constraints directly on s and θ would be non-linear, we instead constrain just a and b . . ." (*Id.* at 5).

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- **“Linear programming:** This results in a constrained L1 minimization problem . . .” (*Id.* at 4).

Thus, Kwatra's method is incapable of minimizing rotational velocity and acceleration of the camera housing. Ex. 2018, ¶¶ 89-90.

Kwatra's References to Rotation

Kwatra's mentions of rotation are incidental. Ex. 2018, ¶ 91. Kwatra's models allow a degree of freedom for image plane rotation, but do not model true 3D rotation of the camera housing:

- **Rotation as Image Degree of Freedom:** Kwatra defines rotation of an image within its linear transformation model (*id.* at 11:5-11), not as camera housing rotation.
- **Rotation Flags Unreliable Feature Matching:** Kwatra flags excessive rotation for quality control, not as an optimization target. *Id.* at 11:63-66.
- **Bounding Constraints:** Kwatra bounds scale and rotation to prevent excessive image transformations but does not minimize rotational velocity or acceleration. *Id.* at 16:31-35.

IX. LEVEL OF ORDINARY SKILL IN THE ART

Petitioner proposes that a POSITA at the time of the '840 patent “would have a bachelor's degree in engineering or computer science, or equivalent field, and two years of experience working on image or video processing, or digital cameras” or “four years of experience working on image or video processing, or digital cameras.” Pet. 5.

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For purposes of this response, Patent Owner applies Petitioner's proposed level of skill. Patent Owner's expert, Dr. Hassan Foroosh, was a POSITA under Petitioner's definition at the time of the '840 patent. Ex. 2018, ¶¶ 17-21.

X. CLAIM CONSTRUCTION

In an *inter partes* review, claim terms receive their plain and ordinary meaning in light of the specification, following the same standard used in district court. 37 C.F.R. § 42.100(b); *see Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005). Petitioner states that no constructions are necessary. See Pet. at 5-6. However, a dispute has arisen regarding the meaning of “low-light high-pass parameter.”

Based on the preliminary arguments, the Board understood a “low-light high-pass parameter” as “a parameter that controls the amount or strength of smoothing used in motion blur compensation.” (I.D. at 8-9). While the Board correctly notes that a low-light high-pass parameter controls the amount or strength of smoothing used in motion blur compensation, the claim terms “low-light” and “high-pass” must also be given meaning. Ex. 2018, ¶¶ 34-43.

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Patent Owner respectfully proposes the following construction:

Claims term	Patent Owner's Proposed Construction
"low-light high-pass parameter"	A parameter that controls the amount or strength of smoothing used in motion blur compensation by allowing more high frequencies to pass through based on low-light conditions.

GoPro's "low-light high-pass" parameter selectively addresses blur from "low-light" conditions while maintaining smoothing strength otherwise. *Id.*, ¶ 37. It also controls smoothing in a specific manner—allowing more high-frequencies to pass, rather than simply attenuating smoothing across all frequencies. GoPro's proposed construction gives meaning to "low-light" and "high-pass." *See Lashify, Inc. v. Int'l Trade Comm'n*, 130 F.4th 948, 964 (Fed. Cir. 2025) ("A claim construction that gives meaning to all the terms of the claim is preferred.")

GoPro's construction is supported by the intrinsic evidence. Ex. 2018, ¶¶ 38-39. The specification explains that the "low-light high-pass" parameter addresses blur caused by longer exposure times in low-light conditions. Ex. 1001 at 18:1-19:59; *see also* at 19:18-21 ("[L]onger exposure time may be used with low light conditions"). Camera motion during exposure—"intra-frame" motion—can cause blur artifacts. *Id.* at 18:1-24; 21:66-22:7. Strong

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smoothing under these conditions can worsen blur, creating “poor visual impression.” *Id.* at 22:2-5.

To address this, the specification describes varying smoothing strength based on exposure time and motion frequency. *Id.* at 18:43-19:26; Figure 7. Certain portions of “high frequencies . . . may be kept based on the image capture configuration.” *Id.* at 17:61-18:1. Thus, output motion can “include high frequencies that mask motion blur within the visual content.” *Id.* at 22:16-21. In this way, the “low-light high-pass parameter” reduces blur caused by low-light conditions while still maintaining stabilization strength elsewhere. *Id.* at 21:64-66.

GoPro's construction is also consistent with the extrinsic evidence. Ex. 2018, ¶ 40. Petitioner's expert Dr. Katsaggelos acknowledges that low-light conditions, indicated by longer exposure times, can cause blur. Ex. 1003 at ¶¶ 111; 123, 237 (“blur may be caused by longer device shutter integration time under low light conditions.”).

However, as Dr. Katsaggelos admitted, blur can arise from “many different reasons,” not just low-light. Ex. 2020 at 103:22-104:8. Thus, the claimed “***low-light***” parameter must be understood as targeting blur from low-light conditions. Ex. 2018, ¶ 41.

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The proposed construction also aligns with the ordinary meaning of “high-pass.” *id.*, ¶ 42. Dr. Katsaggelos testified that a “high-pass” system “allows most of the information of the signal at high frequencies to go through while attenuating the information at the low frequency.” *Id.* at 94:6-15. He also taught students that “high-pass” systems “allow the high frequencies to go through the system unchanged.” Ex. 2022.

For all these reasons, “low-light high-pass parameter” should be construed as “a parameter that controls the amount or strength of smoothing used in motion blur compensation by allowing more high frequencies to pass through based on low-light conditions.” Ex. 2018, ¶¶ 34-43.

XI. GROUND 1: PETITIONER FAILS TO ESTABLISH THAT BELL AND SHI RENDER CLAIMS 1, 14, AND 16 OBVIOUS

A. Claims 1, 14, and 16: Bell and Shi Do Not Disclose Or Render Obvious “Determine a Smoothed Trajectory of the Housing Based On . . . A Low-Light High Pass Parameter . . .”

Claims 1 and 16 require the stabilization system to “determine a smoothed trajectory of the housing based on a look-ahead of the trajectory and

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one or more of a weight-balance parameter, *a low-light high pass parameter*, and/or a stickiness parameter.”² (Emphasis added).

Claim 14 further requires that “*the low-light high-pass parameter controls [the] amount or strength of smoothing performed in smoothed trajectory generation and an extent of motion blur compensation applied in determination of the smoothed trajectory.*” (Emphasis added). The Petition fails to establish that the prior art renders this limitation obvious based on the “low-light high-pass parameter.” Ex. 2018, ¶¶ 92-113.

As discussed above, the claimed “low-light high-pass parameter” means “a parameter that controls the amount or strength of smoothing used in motion blur compensation by allowing more high frequencies to pass through based on low-light conditions.” *Id.*, ¶ 94.

The Petition relies on Shi’s disclosure of a “coefficient” based on a “motion blur kernel” as allegedly disclosing a “low-light high-pass parameter.” Shi addresses blur in a fundamentally different way, *after* determination of

² Petitioner has not asserted that claim 1 is obvious based on any prior art allegedly teaching the other two recited parameters.

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the smoothed trajectory, without regard to light conditions, and in a manner inconsistent with the claimed high-pass system. *Id.*, ¶ 95.

Specifically, Shi's process begins with a stand-alone smoothing process in which "[t]he positions $R(t)$ of the recording device 102 . . . can be filtered to smooth motion over the range, for example, using a Gaussian filter." Ex. 1007 at 12:54-57. The result of this process is an "initial virtual camera position, $V_0(T)$." *Id.* at 12:57-59, 16:41-17:4.

Only after this smoothing is complete does Shi remove "undesirable movement in the device positions or other factors that result in undesired motion." *Id.* at 12:59-62. For example, Shi teaches generating a "second virtual camera position, $V_1(T)$ " by interpolating between $V_0(T)$ and a camera position for the previous frame based on motion over future frames. *Id.* at 13:4-15, 17:5-52. Since interpolation is a low-pass filtering process, $V_1(T)$ is obtained by further low-pass filtering of adjacent frames. *See* Ex. 2018, ¶ 97, n.3.

Shi then teaches generating a "third virtual camera position, $V_2(T)$ " by interpolating $V_1(T)$ with the real device position $R(T)$ based on the amount of camera motion blur present. *Id.* at 13:16-23, 17:53-18:40. As part of this step, Shi estimates a "motion blur kernel" to determine the amount of blur incurred.

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Id. at 18:7-9. Shi does so by comparing projection matrices at the start and end of the exposure period and analyzing motion of a reference offset point.

Id. at 18:10-26.

The motion blur kernel is used to determine a coefficient serving as a weighting factor in spherical linear interpolation (“SLERP”) between the original trajectory ($R(t)$) and second trajectory ($V_1(T)$) to obtain $V_2(T)$. *Id.* at 18:27-40 (teaching interpolation “according to the amount of image blur detected). As Dr. Foroosh points out, SLERP is a low-pass filter that interpolates along the geodesic path on the unit hypersphere between $V_1(T)$ and $R(t)$, represented for example as quaternions or Euler angles. This blending via low-pass filtering is fundamentally different from ’840 patent’s “high-pass” filtering in “low-light” conditions. Ex. 2018, ¶¶ 97-101.

As set forth below, Shi’s disclosures fail to render obvious the claimed requirement that the system “determine a smoothed trajectory based on a look-ahead of the trajectory and . . . ***a low-light high pass parameter*** . . .” *Id.*, ¶ 102.

1. *Shi Does Not “Determine A Smoothed Trajectory” Based On The Purported Low-Light High Pass Parameter.*

First, Shi does not “determine a smoothed trajectory” based on the purported “low-light high-pass parameter,” as the plain claim language

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requires. Ex. 2018, ¶¶ 103-104. In Shi, smoothing is accomplished by determining the first virtual camera position ($V_0(T)$) based on low-pass filtering the positions $R(t)$ of the recording device. Ex. 1007 at 12:54-57 (“The positions $R(t)$ of the recording device 102 over this time period can be filtered *to smooth motion* over the range, for example, using a Gaussian filter.” (emphasis added)). This smoothing process does not involve any consideration of motion blur, nor is it “based on” the purported low-light high-pass parameter. Rather, Shi’s blur correction is performed in a separate, later step. Ex. 2018, ¶ 103.

Shi’s blur correction is also not performed as part of “determin[ing] a smoothed trajectory,” but rather through a new process involving reintroduction of real trajectory data to the already smoothed trajectory using another low-pass filter (SLERP). This is fundamentally different from what the claim language requires. *Id.*, ¶ 104.

2. *Shi’s Parameter is Calculated Independently Of Low Light Conditions.*

Second, Shi’s purported low-light high-pass parameter (the weighting coefficient based on the estimated motion blur kernel) is calculated strictly based on the amount of motion incurred in a given frame. Ex. 2018, ¶¶ 105-106. It is *not* based on low-light conditions. Indeed, Shi does not even mention

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low-light conditions. Petitioner's expert Dr. Katsaggelos confirmed that Shi's motion blur kernel is calculated independently of the cause of the blur and is not tied specifically to low-light conditions. *See* Ex. 2020 at 103:22-104:8 (THE WITNESS: "So it's just understood here that this is a method that is independent of what the cause of the motion blur is."); *id.* at 107:11-108:3 (Q. "This example is not tied specifically to the nature of the lighting conditions; isn't that right, Doctor? . . . THE WITNESS: This example gives us the algorithm of estimating this motion parameter, motion blur parameter. It can be applied to low-lighting conditions, normal lighting conditions. ***It's not tied to any of these situations.*** As long as blur, due to whatever it is, is one way to estimate the magnitude of this blur.") (Emphasis added).

To illustrate why Shi's coefficient is not a low-light parameter: it is entirely possible that Shi's system could calculate a relatively high weighting coefficient for fast-moving objects even in well-lit conditions. Likewise, Shi may calculate a relatively low coefficient for slow-moving or stationary objects even in low-light conditions. This demonstrates that Shi's coefficient is not based on low-light conditions and is ***not*** a low-light high-pass parameter targeted to the specific blur issue addressed by the '840 patent. Ex. 2018, ¶ 106.

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3. *Shi's Parameter Does Not Allow More High Frequency Motion To Pass Through And Thus Is Not A "High Pass" Parameter*

Third, Shi's blur mitigation system does not function as a "high-pass" system—*i.e.*, one allowing more high-frequency motion to pass while continuing to attenuate low frequency motion. Ex. 2018, ¶ 107. Rather, Shi's system performs a spherical linear interpolation (*i.e.* a low-pass filtering using SLERP) between the smoothed and original trajectories, reintroducing both high- and low- frequency motion from the original camera trajectory. *Id.* Because the linear blending of smoothed and original trajectories does not function as a "high-pass" system, this further confirms that the weighting coefficient is not a low-light high-pass system as claimed. *Id.*

4. *Shi's Approach To Blur Management Results In Practical Differences From The Claimed Invention.*

In sum, Shi's approach to blur management operates after determination of the smoothed trajectory to reintroduce original camera motion, regardless of the frequency of motion and without regard to lighting conditions. *Id.*, ¶¶ 108-110. This is vastly different from the claimed approach of determining the smoothed trajectory based on a parameter that controls the amount or strength of smoothing used in motion blur compensation by

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allowing more high frequencies to pass through based on low-light conditions.

Id.

The differences between Shi and the claimed technique have real world implications. *Id.*, ¶ 109. For example, GoPro's invention is directed to cameras designed for fast moving sporting activities like cycling or running where camera shake is a major issue. *Id.* In these circumstances, it makes sense to maintain the strength of smoothing, even at the expense of some motion blur—especially in fast-paced, high-motion scenes. *Id.* Thus, GoPro's low-light high-pass parameter is tailored to a specific type of motion blur—*i.e.*, one that occurs in a “low-light” scenario characterized by longer exposure times—and does so in a targeted way—by allowing high frequencies to pass while attempting to maintain attenuation of lower frequency motion. *Id.* For other scenarios, GoPro's invention prioritizes smoothing of camera shake over concerns about blur. *Id.*

Shi's approach, on the other hand, is directed to cameras on cellular telephones or tablet computers. Ex. 1007 at 1:5-7. For these types of devices, it may make sense to prioritize blur correction, even if it comes at the expense of maintaining smoothing strength. Ex. 2018, ¶ 110. That is why Shi never mentions low-light conditions, and why it does not implement a high-pass

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system for correcting blur. *Id.* Accordingly, Shi's "coefficient based on the motion blur kernel" does not teach nor suggest the claimed "low-light high-pass parameter." *Id.*

5. *A POSITA Would Not Have Been Motivated To Incorporate Shi's Parameter Into Bell With A Reasonable Expectation of Success.*

Even if Shi did disclose the claimed low-light high pass parameter, Petitioner fails to adequately explain why a person of ordinary skill in the art would have been motivated to incorporate Shi's blur-based coefficient into Bell's approach to stabilization with a reasonable expectation of success. Ex. 2018, ¶¶ 111-113.

Bell's stabilization approach is fundamentally based on defining a virtual camera frame within the larger image frame, and then "dampening" or "accelerating" the movement of that virtual camera frame based on its location relative to an "inner region" of a padding space. Ex. 1006, claim 1; *see also id.* at 9:22-25 ("If the hypothetical crop polygon 340 falls outside the inner region, then the virtual camera needs to move faster or slower to match the physical camera and avoid letting the crop polygon go out of frame."). For example, to calculate the virtual position of the camera, Bell discloses a "decay" factor when the prior position is within the inner region, and a

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“mixing weight” when the prior position is outside of the inner region. Ex. 2018, ¶¶ 112.

Thus, a POSITA would have understood that Bell's system is based on a delicate balance of slowing down or speeding up the rate of change of the virtual camera to provide acceptable stabilization while keeping the virtual camera crop window within the boundaries of the image frame. *Id.*, ¶ 113. Petitioner provides no explanation for how Bell's system can accommodate Shi's coefficient based on a motion blur kernel without compromising the balance that Bell establishes between dampening and accelerating the virtual camera motion. *See Juniper*, --- F.4th ---, 2024 WL 3517862, at *6 (Fed. Cir. July 24, 2024) (“It was Juniper's burden to establish a reasonable expectation of success, and Juniper presented no theory other than that the combination was simple.”); *Adidas AG v. Nike, Inc.*, 963 F.3d 1355, 1358-59 (Fed. Cir. 2020) (affirming finding of no motivation to combine where proposed modification to primary reference would “require the alternation of the principles of operation” or render primary reference “inoperable for its intended purpose”). Neither Petitioner nor its expert considered or addressed this interaction and thus have failed to establish that their purported combination renders the claim limitation obvious.

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B. Claims 1 and 16: Bell and Shi Do Not Disclose Or Render Obvious the Claimed “Temporal Horizon Enabling Approximation of Intentional Motion”

Claims 1 and 16 require: “the determination of the smoothed trajectory based on the look-ahead of the trajectory includes use of a temporal horizon of motion experienced by the image capture device, the *temporal horizon enabling approximation of intentional motion* of the image capture device while causing a delay in the determination of the smoothed trajectory.”

The '840 patent teaches that because intentional motion “may be characterized by lower frequency motion than unintentional motion,” intentional motion can be identified by considering a “sufficiently long temporal horizon of experienced motion.” Ex. 1001 at 9:17-23. Thus, in implementing the claimed “look ahead,” the '840 patent teaches a tradeoff between processing delay and accuracy in estimating whether a given motion is an intentional motion. *Id.* at 9:25-28 (“Longer intervals of the temporal horizon may enable better approximation of the intentional motion while causing longer delays (longer wait to determine smoothed trajectory).”). Bell and Shi make no such tradeoff; they apply short buffering and fixed heuristics to avoid abrupt virtual camera changes—not to approximate user intention. Ex. 2018, ¶¶ 114-127.

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1. *Bell Fails To Teach Or Suggest A Temporal Horizon For Enabling Approximation Of Intentional Motion.*

Petitioner contends that Bell discloses a “temporal horizon enabling approximation of intentional motion” because it “define[s] a new virtual camera that stays static when the motion is so small that the intention is probably that the camera should remain static.” Pet. at 39 (citing Ex. 1006, 8:52-55). Petitioner also cites Bell’s statement that “[i]f frames can be buffered within the camera pipeline for a short time before being processed, then a larger time window of motion sensing system data can be examined, and sharp changes can be preemptively avoided.” *Id.* (citing Ex. 1006 at 10:10-13). From this, Petitioner concludes that Bell uses motion experienced during future frames to “approximate intentional motion.” *Id.* at 39-40.

Petitioner’s argument conflates two distinct aspects of Bell’s system and mischaracterizes both. Understood in context, Bell does not disclose a “temporal horizon enabling approximation of intentional motion.” Ex. 2018, ¶¶ 117-124.

First, Bell’s primary method of determining whether and by how much to move the virtual camera does not involve any look-ahead, temporal horizon, or approximation of intentional motion. *Id.*, ¶ 118. Bell’s stabilization technique uses a “crop polygon” to track the motion of a “virtual camera”

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between frames and adjust the center of the view accordingly. *Id.* For any given frame, the orientation of the virtual camera is initially determined based only on *past information*—*i.e.*, a multiplication of the virtual camera orientation from the prior frame by the virtual camera velocity in that prior frame. Ex. 1006 at 9:1-5 (describing “Relation 4”). This technique does not involve any consideration of a temporal horizon or any approximation of intentional motion. Ex. 2018, ¶ 118.

To maintain a stable and bounded virtual camera path, Bell also conceptualizes a “padding space” with an “inner region” and an “outer region.” Ex. 1006, 9:16-20. If, for any given frame, the virtual camera is located within the inner region, the calculation provided by Relation 4 is adopted, and Bell applies a “decay factor” to slow down the rate of change of the virtual camera. *Id.* at 9:20-36. This has the effect of dampening the rate of change of the virtual camera. Ex. 2018, ¶ 119. Alternatively, if part of the virtual camera falls outside the inner region of the padding space, a “mixing weight” is applied to speed up the angular change of the virtual camera. Ex. 1006, 9:43-10:7. This process of applying dampening and acceleration factors is based entirely on the newly calculated virtual camera orientation relative to a fixed

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padding space—again, it makes no use of any look-ahead, a temporal horizon, or any approximation of intentional motion. Ex. 2018, ¶ 119.

Second, Bell notes that while the previously described “algorithm works well,” it “occasionally has to make quick changes in velocity when the crop polygon suddenly hits the edge.” Ex. 1006 at 10:8-10. Only in this context—*i.e.*, to avoid abrupt corrections—does Bell propose “a small buffer of future frames, e.g., five or less,” *id.* at 8:66-67, and only for the purpose of ensuring that “sharp changes can be preemptively avoided,” *id.* at 10:10-16; Ex. 2018, ¶ 120.

Bell’s look-ahead is thus limited to projecting the crop polygon 2 to 5 frames into the future for the purpose of determining whether the crop polygon will lie outside the inner region at future time. Ex. 1006, 10:17-25. If the crop polygon is projected to lie outside the inner region, Bell teaches to apply a “mixing factor” to further increase the velocity of the virtual camera and provide it with a “preemptive nudge in the right direction.” *Id.* at 10:25-37. Significantly, Bell does ***not*** update the previously calculated virtual position of the camera based on the lookahead as would be expected from a system seeking to approximate intentional motion—Bell merely changes the velocity used in calculation of the next frame. *Id.* at 10:34-37; Ex. 2018, ¶ 121.

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Thus, while Bell does teach a very short “look ahead,” it does so only for the limited purpose of predicting whether the virtual camera will approach the frame boundary at a future time so that a further correction value may be preemptively applied to avoid “abrupt” corrections in the future. Ex. 2018, *Id.*, ¶ 122. This does not teach the use of the temporal horizon for purposes of approximating whether motion at a current time is intentional. *Id.* Bell’s limited look-ahead, is merely a safeguard to prevent the crop polygon from drifting too close to the boundary, resulting in a sudden corrective movement at a future time. *Id.*

Indeed, according to Bell’s teachings, the dampening and acceleration factors are applied without regard to whether actual camera motion at the current time was intentional or not. *Id.*, ¶ 123. Rather, Bell applies these correction factors based strictly on whether current and future frames fall outside the inner region of the padding space. *Id.*

Accordingly, Bell does not disclose or suggest the claimed “temporal horizon enabling approximation of intentional motion.” *Id.*, ¶ 124.

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2. *Shi Likewise Fails To Teach Or Suggest A Temporal Horizon For Enabling Approximation Of Intentional Motion.*

As a fallback, Petitioner contends that Shi discloses the temporal horizon limitation, because Shi's "system can reduce the impact of large or sudden movements using look-ahead frames" and "evaluate whether consistent movement, such as panning, is occurring and adjust the video frames to reflect the consistent movement." Pet. at 40 (citing Ex. 1007, 5:17-24). Neither of these assertions withstand scrutiny. Ex. 2018, ¶¶ 125-127.

First, Shi's use of look-ahead frames to "reduce the impact of large or sudden movements" does not teach the use of a temporal horizon to enable an approximation of intentional motion as claimed. *Id.*, ¶ 126. In fact, Shi's approach contradicts the claimed approach, because it involves intentionally introducing motion to frames where the system determines that no motion actually exists. *Id.* For example, Shi explains that "for a current frame under analysis, the position of the recording device may not have moved significantly since the previous frame." Ex. 1007 at 10:46-49. "*Nevertheless*, Shi teaches, "if the engine 170 determines that significant motion occurs in future frames, the second transformation 172 can be generated to *shift or otherwise alter the current frame to introduce apparent movement in the*

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video, so that large future movement can be spread out as a series of gradual changes rather than an abrupt change.” *Id.* at 10:49-54. This is the opposite of the using a temporal horizon to enable approximation of intentional motion—Shi teaches a different approach of intentionally *altering* motion across frames to avoid abrupt to sudden changes. Ex. 2018, ¶ 126.

Second, Petitioner's reliance on Shi's disclosure of “evaluat[ing] whether consistent movement, such as panning, is occurring,” Pet. 40 (citing Ex. 1006 at 5:22-24) is similarly misplaced. Ex. 2018, ¶ 127. Shi teaches that this technique involves calculation of a fourth virtual camera position ($V_3(T)$) that “is generated by filtering the device patterns to conform to a predetermined, consistent motion pattern.” Ex. 1006 at 13:35-40. Shi itself admits that this technique “impose[s] a *predetermined* shape or pattern,” *id.* at 13:35, as distinguished from prior filtering steps that “smooth[] but generally follow[] the changes in estimated actual device positions over time,” *id.* at 13:32-34. This approach of “imposing” a predetermined shape or pattern is not the same as using the temporal horizon to “enable approximation of intentional motion” of the image capture device. Ex. 2018, ¶ 127. In fact, a POSITA recognizes that resort to such a “heuristic”-based approach indicates an inability of the system to implement the claimed temporal horizon to enable

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approximation of intentional motion while determining a smoothed trajectory as claimed. *Id.*

XII. GROUNDS 2-4 AND 6-7 FAIL ON THE MERITS

Petitioner asserts that the combination of Bell and Shi in combination with various other references render the remaining dependent claims of the '840 patent obvious. However, except for claim 13 (addressed below), these combinations fail for the same reason as Ground 1. *Id.*, ¶ 128.

XIII. GROUND 5: PETITIONER FAILS TO ESTABLISH THAT BELL, SHI, AND KWATRA RENDER CLAIM 13 OBVIOUS

Dependent claim 13 further requires that “*the weight-balance parameter controls types of motion that are minimized* in smoothed trajectory generation, the types of motion *including rotational velocity and rotational acceleration.*” (Emphasis added). Petitioner fails to establish that this claim is obvious. *Id.*, ¶ 129.

A. Claim 13: Kwatra Does Not Disclose Or Render Obvious The “Weight-Balance Parameter” For Controlling Rotational Velocity and Rotational Acceleration

As in IPR2024-01186, Petitioner relies on Kwatra's disclosures about optimizing certain *linear motion models* (Ex. 1012). These disclosures fail to teach or suggest a “weight balance” parameter for controlling the extent to which rotational velocity and rotational acceleration are minimized. Ex. 2018,

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¶¶ 129-157. Kwatra, in fact, intentionally avoided the type of non-linear calculations that minimizing *rotational* velocity and acceleration would entail. *Id.*, ¶ 130.

1. *Kwatra's Linear Framework Does Not Provide For Controlling Minimization Of Rotational Velocity And Rotational Acceleration Of The Housing As Required*

Due to concerns regarding computational constraints, Kwatra's motion estimation and smoothing approach is fundamentally based on linear motion models. Thus, Kwatra's technique is incapable of controlling or balancing the minimization of rotational velocity and rotational acceleration. *Id.*, ¶ 131.

Kwatra discloses a video stabilization method that estimates camera motion by tracking image features across frames and fitting *linear motion models* to the detected feature motion. Ex. 1012, 13:23-14:52. The motion trajectory is then smoothed using an optimization framework that minimizes derivatives for segments of the estimated motion path based on a linear cost function. *Id.*, 1:48-57, 2:6-14, 6:1-28, 6:40-42, 13:23-48; Ex. 2018, ¶ 132.

Kwatra's approach begins with an analysis of the image information to determine an "original camera path" (C(t)). First, "trackable features between two frames may be extracted by extracting a number of features in a first video frame (e.g., based on x and y location) and tracking the extracted features in

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a next video frame.” Ex. 1012 at 7:58-62. Once features are extracted and tracked, “two-dimensional (2D) linear motion models” are “fit to the trackable feature-matches to describe motion of the camera between video frames. *Id.* at 9:51-45. “An estimate of the original camera path ($C(t)$) can be determined by fitting linear motion models to the tracked feature pair matches resulting in a linear transform for each feature pair.” *Id.* at 9:57-60. The original camera path $C(t)$ is a simple concatenation of the linear 2D motion models for feature-pair matches between consecutive frames. *Id.* at 12:11-21; *see also* claim 6; Ex. 2018, ¶ 133.

Kwatra then conceptualizes a “smooth” or “optimal” camera path ($P(t)$), wherein $P(t)$ is defined as:

$$P(t)=C(t)*B(t)$$

where $C(t)$ represents the estimated original camera path and $B(t)$ is a linear transformation matrix applied to each frame to generate a stabilized sequence. Ex. 1012, 13:52-56; Ex. 2018, ¶ 134.

Petitioner contends that the cost function (Equation 7) discloses that the first, second, and third derivatives of the smoothed camera path $P(t)$ are minimized:

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$$a \left| \frac{dP}{dt} \right| + b \left| \frac{d^2 P}{dt^2} \right| + c \left| \frac{d^3 P}{dt} \right|$$

Ex. 1012, 13:62-14:12.

However, minimizing the derivatives of the smoothed camera path as discussed in Kwatra does **not** result in minimization of a combination of **rotational** velocity and acceleration. Ex. 2018, ¶ 135-136. As the discussion from columns 14 through 15 make clear, the derivatives in column 7 are computed strictly as a function of the *linear* transforms between a series of consecutive frames. *See, e.g.*, Ex. 1012 at 14:54-15:56. Equation 12, for example, makes this clear. Equation 12 expresses the linear frame-pair transform that represents motion from a first position (x_1) to a second position (x_2) based on linear relationship between four degree of freedom parameters (a_t , b_t , c_t , and d_t) and the translation in the x and y dimensions (dx_t and dy_t). Ex. 2018, ¶ 136.

As the Board recognized in its Institution Decision, Kwatra does teach that the 2-dimensional linear motion model may be represented as a “similarity” or “affine” transformation with degrees of freedom for scale and rotation. Ex. 1012 at 11:3-21. Kwatra, however, expressly rejects an approach

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that minimizes rotation or scale in its smoothing/optimization step. Ex. 2018, ¶ 137.

As an initial matter, it is important to note that the rotation degree of freedom parameter discussed in Kwatra refers to the rotation of a trackable feature in an image, *not* rotation of the camera housing. *Id.*, ¶ 138. As discussed below, rotation of a trackable feature and rotation of the camera housing are not the same. *Id.* Even more fundamentally, however, despite teaching motion models that may include a rotation or scale parameter, Kwatra expressly rejects an approach that would attempt to minimize these changes to rotation or scale as part of its smoothing/optimization step. *Id.*

Specifically, for similarity or affine transformations, Kwatra teaches to impose smoothness constraints only on the degree of freedom parameters “a” and “b,” rather than directly on the scale (“s”) and the image rotation angle (“ θ ”) of trackable features. Ex. 1012, 17:5-20. Kwatra acknowledges that this approach of constraining smoothness on only a and b results in a path where “rotation and scale may not remain smooth.” *Id.* at 17:11-18. To address this issue, Kwatra teaches instead to place bounding constraints (*i.e.*, numerical limits) on changes to scale and rotation in the smoothed camera path “to ensure s and theta do not deviate too much.” *Id.* 17:19-20.

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Thus, Kwatra itself recognizes that its linear optimization model does not result in a smoothed theta—*i.e.*, it does not minimize any derivatives of theta. Ex. 2018, ¶¶ 138-140. As Kwatra teaches, this simplification is necessary because “imposing smoothness constraints on s and theta may be non-linear,” Ex. 1012 at 17:18-19, which would subvert Kwatra’s consistent teaching for linear models and using linear programming. Ex. 2018, ¶ 140.

It is also worth noting that Kwatra does not even teach bounding theta itself but rather discloses bounding the sine or cosine of the image rotation angle, which is not the same as bounding the image angle theta itself. Ex. 1012 at 17:37-38. But more importantly, placing bounds on the extent the scale s and the $\cos(\text{theta})$ or $\sin(\text{theta})$ are allowed to change during estimation of the camera path is not the same as controlling a minimization of rotational velocity and rotational acceleration of the camera housing. Ex. 2018, ¶ 141.

Kwatra’s provisional application (Ex. 2019), which is incorporated into Kwatra by reference, Ex. 1012 at 1:8-11, provides further explanation and support for the foregoing understanding. The provisional application notes how the “optimal algorithm could estimate all parameters for all frames jointly,” however this “concatenation of parameters is not linear anymore, requiring a more complex, non-linear optimization method *which is not fast*

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enough for real-time performance.” Ex. 2019 at 6 (emphasis added). Kwatra’s inventors noted that they “therefore opt for a simpler linear update scheme” *Id.* “To preserve our linear framework,” Kwatra assumes that “*the rotation and scale components of A are small enough* that if we would transform the frame window corners, they would not move by more than the distance to the nearest crop corner.” *Id.* at 10 (emphasis added).

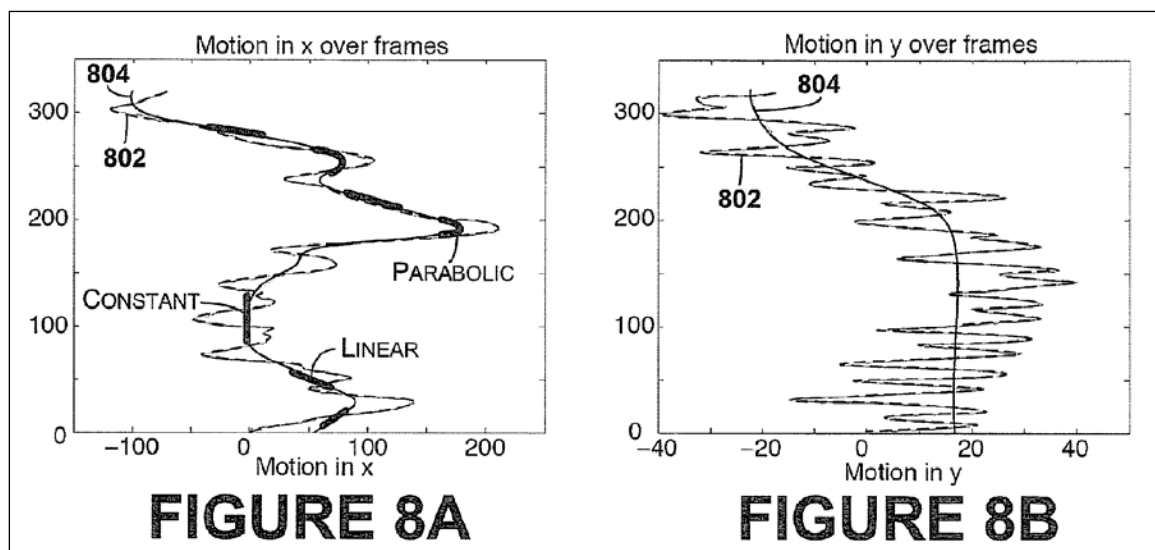
Thus, by deliberately avoiding non-linear computations, Kwatra does not and cannot control any minimization of rotational velocity and acceleration of a camera housing path. Ex. 2018, ¶¶ 142-143. Kwatra thus does not teach or suggest any weight-balance parameter. *Id.*

In forming his invalidity opinions, Dr. Katsaggelos did not review Kwatra’s provisional application which was incorporated by reference in Kwatra. *See* Ex. 2020, Depo. Tr. at 19:25-20:5 (“Q. So in forming your invalidity opinions, you did not review the provisional application that the inventors in Kwatra filed; is that correct? . . . THE WITNESS: This is a document that -- application that I did not analyze.”). Thus, Dr. Katsaggelos was not aware of and did not consider the inventors statements that they avoided more complex nonlinear optimization methods, as “not fast enough for real-time performance.” *See id.* at 21:1-14 (“Q. Do you understand what’s

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being described there? . . . THE WITNESS: As I mentioned, I haven't analyzed this document. So I cannot offer an opinion just on the fly by just looking at a sentence or two.”).

Further demonstrating that Kwatra fails to render the weight-balance parameter limitation of claim 13 obvious are Kwatra Figures 8A and 8B and their associated description. Ex. 2018, ¶¶ 145-146. Figures 8A and 8B depict the “original camera path motion 802 versus an updated or smooth camera path motion 804.” Ex. 1012 at 19:4-6. Kwatra states that Figures 8A and 8B are depicting the “optimal L1 path” comprised of segments with minimized derivatives of the smooth camera path $P(t)$ consistent with Equation 7. Yet, Figures 8A and 8B track camera motion (both original and smooth) exclusively as a function of position in the X and Y dimensions, respectively.



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Figures 8A and 8B make clear that Kwatra's aim is not to control the minimization of any combination of rotational velocity and rotational acceleration. Ex. 2018, ¶ 146. Indeed, Petitioner's own expert at trial, Mr. Goodin, conceded that a POSITA would understand Kwatra's smoothed motion model "P," as represented in Figure 8, to be translational, not rotational. Ex. 2021, Tr. (Goodin) 1368:6-1369:7. And, of course, there is no teaching or suggestion in Kwatra that results in any smoothed camera position as function of a rotational position or angle. This directly contradicts Petitioner's assertion that Kwatra teaches minimizing rotational velocity and acceleration of the camera housing. Indeed, Kwatra's express rejection of non-linear optimization precludes it from teaching or suggesting the claimed weight-balance parameter of claim 13 of the '840 patent. Ex. 2018, ¶ 146.

2. *Kwatra's Two-Dimensional Approach To Motion Estimation And Optimization Is Inconsistent With Controlling A Minimization Of Rotational Velocity And Rotational Acceleration Of The Housing As Claimed*

Moreover, Dr. Katsaggelos conceded at deposition that modeling rotational velocity of a camera housing requires a three-dimensional model. Ex. 2020 at 79:2-22 ("Q. Can you have angular velocity considered in a two dimensional model? . . . THE WITNESS: The two dimensional models we talk about cannot – cannot cover that, cannot cover the camera rotation in the

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3D space, cannot cover the ang[ular] velocity of the camera. I need a 3D model to be able to capture this quantity.”). Kwatra’s motion estimation and optimization techniques, however, are consistently described in the context of *two-dimensional* linear models. Ex. 1012 at 9:41-43 (“two-dimensional (2D) linear motion models (e.g., translation, similarity, affine) can be fit to the trackable feature-matches . . .”), at 19:39-41 (“As described above using the example methods shown in FIGS. 3-4, a 2D original camera path $C(t)$ may be first estimated, and a new camera path $P(t)$ can be determined.”).

While Dr. Katsaggelos opined that Kwatra suggested modeling and optimizing motion in three dimensions, he failed to identify anything in the reference that actually discloses such an approach. For example, despite using the word “dimensional,” Kwatra’s mention of “estimates from lower to higher dimensional motion models (e.g., similarity --> homography)” at column 11, lines 58-61 is understood by a POSITA as merely referring to an estimate of a 2D model with more degrees of freedom (*i.e.*, a homography transform) from another 2D model with fewer degrees of freedom (*i.e.*, a similarity). *See* Ex. 2018, ¶¶ 147-150. Again, the actual motion modeling and optimization disclosures of Kwatra relied upon by Petitioner are exclusively described in

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the context of 2D models. Nowhere does Kwatra teach or disclose a method for modeling or optimizing three-dimensional motion.

Thus, because the motion modeling and optimization that Petitioner relies upon is based upon a 2D model, and because Petitioner's expert agrees that controlling the minimization of rotational velocity and rotational acceleration inherently requires a three-dimensional model, Kwatra fails to disclose or render obvious the claim limitation. Petitioner's theory fails for this independent reason. *Id.*

3. *Kwatra Solves for a Linear Transform $B(t)$ of Each Video Frame, Not for a Trajectory that Minimizes Rotational Velocity and Acceleration of a Camera Housing*

The Petition also fails to disclose the weight-balance parameter, because it conflates minimizing derivatives of what Kwatra refers to as the smooth camera path $P(t)$ with controlling minimization of rotational velocity and acceleration of a **camera housing** as required. Ex. 2018, ¶¶ 151-157.

Independent claim 1 makes clear that claimed system “determine[s] a smoothed trajectory **of the housing**” that results in “smoother changes in the rotational positions of the housing than the trajectory.” In this context, a POSITA understands that the claimed “weight-balance” parameter of claim 13 must control the “rotational velocity and rotational acceleration” of the

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housing, as opposed to specific tracked features within the captured image.

Id., ¶ 152.

Kwatra fails to disclose this aspect of the claims. *Id.*, ¶ 153. As discussed above, Kwatra's motion model is based on extracting and tracking feature pairs across successive frames. *Id.* Thus, Kwatra's "camera path" does *not* represent the motion of the physical camera housing in space, but rather "describe[s] motion of pixels between frames—such as feature moved 10 pixels to the right, equivalent to movement of the camera to the left by 10 pixels." Ex. 1012 at 9:49-54.

The number of pixels that a particular feature moves across a frame is *not* equivalent to the amount of rotation of the camera housing in three-dimensional space. Ex. 2018, ¶ 154. Rather, the relationship between movement of a feature and motion of the camera depends critically upon the distance of that trackable feature from the camera. *Id.* For example, a background feature and a foreground feature at different depths will move by a different number of pixels for a given displacement of the camera housing in physical space. *Id.* Petitioner's expert admitted this fact at his deposition, Ex. 2020 at 52:13-21, but did not account for it in his analysis.

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Thus “minimizing” derivatives of Kwatra’s “camera path,” at most, minimizes the apparent motion of pixels for some composite set of features in the image. Ex. 2018, ¶¶ 155-156. Petitioner fails to demonstrate how this results in the minimization of a combination of rotational velocity and acceleration *of the camera housing* as required. *See Univ. of Strathclyde v. Clear-Vu Lighting LLC*, 17 F.4th 155, 160-62 (Fed. Cir. 2021) (reversing obviousness decision in IPR where substantial evidence did not support finding that prior art taught all claim limitations).

The failure of Kwatra to teach or disclose an approach that controls minimization of the camera housing speaks to the fundamental differences between Kwatra and the ’840 patented approach. Ex. 2018, ¶ 157. Kwatra is directed to optimizing a 2D path based on linear motion models extracted from trackable features. The ’840 patent, by contrast, is directed to optimizing the trajectory of a video so that it appears as if it were captured by a camera whose housing underwent a minimal combination of rotational velocity and rotational acceleration *of the camera* during capture. Kwatra fails to render the claim obvious for this independent reason. *Id.*

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B. A POSITA Would Not Have Been Motivated to Combine Bell, Shi, and Kwatra

The Petition fails to account for the fundamental different image stabilization techniques employed by Bell and Shi on the one hand, and Kwatra on the other hand. *Id.*, ¶¶ 158-164. The embodiments that Petitioner relies upon from Bell and Shi teach video image stabilization strategies, implemented in mobile devices that make use of an on-board position sensor to estimate the 3-dimensional motion of the mobile device. *Id.* Kwatra, on the other hand, teaches a post-processing, server-based approach that estimates motion through feature tracking within the image data. Ex. 1012 at 3:47 (“In one example, a video may be stabilized by performing post-processing techniques.”), at 5:21-26 (“The video hosting service 200 comprises the camera path translation system 202, a video server 210, an ingest server 212, and a video database 216.”); *see also* FIG. 2.

While Petitioner's expert contends that Kwatra contemplates implementing its techniques in a mobile device, this assertion is unsupported and contradicted by Kwatra itself. Ex. 2018, ¶ 159. For example, while Dr. Katsaggelos cites Figure 13 and its associated discussion, Ex. 1002 at ¶ 117, that discussion merely provides that generic “computing device 1300” can comprise a server or a mobile device and “may be implemented as a client

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device, a server, a system, a combination thereof, or as a portion of components *described in FIGS. 1-2.*” Ex. 1012 at 26:11-21 (emphasis added). Figures 1 and 2 provide an architecture in which the “camera path translation system” (202) is implemented exclusively in the “video hosting service” (200) and only communicates with mobile “client” devices (204) through a “network” (206). Thus, while Kwatra’s disclosure of generic “computing device 1300” is broad, Kwatra teaches that this computing device is for implementing components of the specific architecture of Figure 2 in which camera path estimation and modeling are performed exclusively in a server-based system. Ex. 2018, ¶ 159.

This understanding of Kwatra is consistent with the relevant state of the art. *Id.*, ¶ 160. A POSITA would have recognized that solving for a complex, multi-derivative trajectory optimization problem was a computationally intensive process that was not considered suitable for a resource-constrained mobile device. *Id.* Moreover, performing this sort of trajectory optimization on a real-time stream of three-dimensional gyroscope data (*i.e.*, like that collected by systems disclosed in Bell and Shi) would have been a complex, challenging endeavor that is not contemplated by any of the prior art of record. *Id.* A POSITA would have recognized that Kwatra’s server-based, post-

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processing optimization of two-dimensional linear motion models was not compatible with Bell/Shi's mobile-device based stabilization of three-dimensional rotational data. *Id.* Nor is there any reason to believe that a POSITA would have had a reasonable expectation of success in attempting to perform this combination. *Id.*

Petitioner's expert admitted that the image-based approach of motion estimation taught by Kwatra was a different approach from the gyroscope based motion estimation approach taught by Shi and Bell. Ex. 2020 at 14:12-19; *see also* Ex. 1004 at 1:29-34 (teaching that stabilizing a video by tracking salient features requires "a priori knowledge of the image's content to, for example, identify and track a person or other salient object in the scene.").

Moreover, Bell explains why a POSITA implementing a gyroscope-based system would not be motivated to look to the image-based systems like Kwatra:

Using the on-board multi-axis motion sensing system of a mobile phone or other device for motion tracking has a number of advantages. ***Filtering and analyzing the motion sensing system measurements in real time requires much less processing power in comparison to trying to estimate camera rotations from the image data after the fact.*** Motion sensing system estimates can be calculated with a relative few multiplications and additions, while ***image-based methods require processing on thousands or even millions of picture elements.*** Additionally, image-based motion estimation methods can fail

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when features are sparse or when large objects move in the foreground. A motion sensing system, by contrast, always reports the device motion regardless of how much and in which direction(s) the objects in the scene move.

Ex. 1006 at 6:45-59. This passage underscores the clear differences between the two alternative approaches to motion sensing and smoothing and demonstrates why a POSITA would not consider the teachings from one to be easily substituted into the other. Ex. 2018, ¶ 162.

Petitioner's asserted motivation to combine is conclusory and unsupported by substantial evidence, merely suggesting—without detailed analysis or explanation—that combining Bell and Shi's 3D sensor-based approaches with Kwatra's 2D image-based linear optimization would yield better stabilization results. *Id.*, ¶ 163. Such generalized assertions are insufficient to establish obviousness. *See Teleflex, Inc. v. Ficosa North America Corp.*, 299 F.3d 1313, 1334 (Fed. Cir. 2002).

Given the clear computational and functional disparities between the references, there is no persuasive motivation or reasonable expectation of success for a POSITA to combine Bell and Shi with Kwatra. *Id.*, ¶ 164. Therefore, the Petition fails to demonstrate obviousness and claims 1-21 should be upheld. *Id.*

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XIV. SECONDARY CONSIDERATIONS CONFIRM NON-OBVIOUSNESS

Secondary considerations, or “objective indicia,” of non-obviousness are critical in the overall inquiry under § 103. As the Federal Circuit has noted, these indicia can “often establish that an invention appearing to have been obvious in light of the prior art was not.” *See Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1538 (Fed. Cir. 1983); *Liqwd, Inc. v. L’Oreal USA, Inc.*, 941 F.3d 1133, 1136-37 (Fed. Cir. 2019). Objective indicia “‘may often be the most probative and cogent evidence’ of nonobviousness.” *Liqwd*, 941 F.3d at 1136. When a nexus exists between these secondary considerations and the claimed invention, this evidence can carry substantial weight. *See Rambus Inc. v. Rea*, 731 F.3d 1248, 1256 (Fed. Cir. 2013).

Moreover, as emphasized in *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007), secondary considerations help avoid hindsight bias, which can distort the obviousness inquiry. Objective indicia anchor the analysis in market reality, not hindsight.

In considering secondary consideration evidence, the Board should conduct a “a reasoned, collective weighing of its evidence of secondary considerations,” and not rely on “overly vague and ambiguous” “assignments

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of weight to different considerations.” *Volvo Penta of the Americas v. Brunswick Corp.*, 81 F.4th 1202, 1213-16 (Fed. Cir. 2023).

A. Nexus

Here, secondary considerations—commercial success, industry praise, long-felt need, failure of others, unexpected results, and copying—are directly attributable to the unique stabilization approach claimed in the '840 patent. Ex. 2018, ¶¶ 199, 165-224. GoPro's HERO7 Black's HyperSmooth system leverages a weight-balance parameter to adjust the emphasis between rotational velocity and acceleration, a low-light high-pass parameter to preserve high-frequency motion in low-light conditions, and a temporal horizon to approximate intentional motion. *Id.*, ¶ 199. This multifaceted optimization represented a substantial departure from prior approaches like Shi's blur-detection-based blending or Kwatra's linear image-driven smoothing, enabling GoPro to achieve stabilization praised by consumers and industry experts alike. *Id.*

Here, Dr. Foroosh has confirmed that HERO7 Black's implementation of HyperSmooth embodies each and every limitation of claims 1, 13, and 14 of the '840 patent. *See* Ex. 2018 at ¶¶ 166-198. While Petitioner disputes that HERO7 Black meets limitation 1[g(iii)]—requiring a temporal horizon

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approximating intentional motion and introducing a processing delay—that argument mischaracterizes the HERO7's stabilization. *Id.*, ¶ 200.

Dr. Foroosh independently confirmed that HERO7 Black includes a temporal horizon as understood by a POSITA. *Id.*, ¶ 201. Specifically, the HERO7 Black includes a sufficiently long temporal horizon to detect intentional motion, introducing the necessary delay as required by limitation 1[g(iii)]. [REDACTED]

[REDACTED]

[REDACTED]

In addition, HyperSmooth's transformative stabilization depends on the other patented features: the low-light high-pass parameter (Claims 1 and 14) and the weight-balance parameter (Claims 1 and 13). *Id.*, ¶ 202. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

The HERO7 Black was the first GoPro product to commercialize HyperSmooth and embody the claimed inventions of the '840 patent. *See* Ex. 2024 (Lema Decl.), ¶¶ 6, 10. Its launch marked a paradigm shift for GoPro and the industry, driven by HyperSmooth's capabilities. *See id.* at ¶ 10. The

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resulting commercial success and industry recognition—including HERO7 Black being called one of GoPro's most important releases—were directly tied to the stabilization enabled by the '840 patent. *See id.* at ¶ 11.

Accordingly, the HERO7 Black's commercial success, industry praise, and copying by competitors are specifically tied to the patented features. The record thus establishes a clear nexus between the '840 patent and the secondary considerations supporting non-obviousness. Ex. 2018, ¶¶ 166-204.

B. Commercial Success

GoPro's HyperSmooth technology, which practices the '840 patent, has driven significant commercial success. Ex. 2018, ¶¶ 205-210. According to GoPro's head of product, Mr. Pablo Lema:

The release of HyperSmooth was a “shock to the market.” HERO7 Black became the fastest-selling production launch in GoPro's history at the time. Our sales jumped 170% compared to HERO6 in the same post-launch window, driven almost entirely by the introduction of HyperSmooth. From a feature standpoint, the HERO6 camera is nearly indistinguishable from the HERO7 Black with the exception of HyperSmooth.

Ex. 2024 at ¶ 11.

Mr. Lema also cited internal survey data confirming that HyperSmooth and immersive lens options were among “the most important and valued features driving customer demand across our HERO customer base,” and that

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GoPro's "product planning decisions—including resource allocation and feature prioritization—relied heavily on this data." *Id.* at ¶19.

Specifically, in a [REDACTED] (Ex. 2040, also Ex. A to Lema Dec., CX-590C), "Advanced video stabilization" ranked as the top feature for the Core HEROes segment and among the top three for the market segments representing GoPro's historical customer base. *Id.* at ¶¶14-19.

In a separate [REDACTED] (Ex. 2041, also Ex. B to Lema Dec., CX-649C), HERO11 Black buyers selected "Advanced video stabilization (HyperSmooth 5.0 with AutoBoost)" as the #1 driver of purchase—above all other features. *Id.* at ¶ 20.

These results, according to Mr. Lema, "reflect the role that GoPro's patented stabilization and lens features play in driving consumer demand and purchasing behavior." *Id.* at ¶ 21. He concluded that "the patented technologies in the '894, '840, '832, and '413 patents were directly responsible for GoPro's sustained commercial success with HERO cameras, especially from the HERO7 onward." *Id.*

GoPro's dominant position in the U.S. action camera market—holding more share than all competitors combined—further illustrates the commercial strength of its patented technologies. Partnerships with brands like Red Bull,

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NHL, and Adobe underscore this market confidence. *See* Ex. 2005 (NHL Senior VP of Programming and Production said, “[O]nly GoPro has the technology to help us and our media partners showcase the beauty and intensity of hockey in new and deeper ways.”); Ex. 2008 (GoPro “named the exclusive action camera of Red Bull” mountain bike competition; GoPro athletes will capture their runs wearing HERO11 featuring “GoPro’s Emmy Award-winning HyperSmooth video stabilization”); Ex. 2009 (Vice President of Adobe Stock said, “Adding GoPro’s unique footage to Adobe Stock gives our community access to a library of immersive ‘wow’ moments”).

C. Industry Praise and Recognition

GoPro’s HyperSmooth technology has received widespread industry recognition, including a 2019 CES Innovation Award and a 2022 Technology and Engineering Emmy. *See* Ex. 2010 (“In Camera Sensor and Software Stabilization – Awarded to GoPro and Socionext” . . . “The technology has created the ability for camera operators and producers to obtain stabilized action footage when a subject is rapidly moving easily and economically in unstable situation.”); Ex. 2011; Ex. 2012 (“This Emmy is in recognition of the technology powering GoPro’s industry-leading HyperSmooth video stabilization”); Ex. 2018, ¶ 211.

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Mr. Lema confirms, “GoPro won the 73rd Technology and Engineering Emmy award specifically for its in-camera sensor and software image stabilization, introduced with HERO7.” Ex. 2024 at ¶¶ 13, 22. He also notes “a vast amount of industry praise for HyperSmooth and HERO7” in the form of customer reviews, publications, and tech blogs. *Id.* at ¶ 23. These technologies enabled “a step-change” in user experience that drove demand, growth and recognition for GoPro’s products. *Id.* at ¶ 24.

Third-party reviews echo this view. Analysts at JP Morgan called GoPro’s “gimbal like hypersmooth stabilization (developed in-house . . . a significant upgrade” and “key selling point” for the HERO7. Ex. 2013.; Tech reviewers wrote: “GoPro’s HyperSmooth image stabilization is the best we’ve seen on any action camera.” Ex. 2014 at 5.

Technical reviews of the subsequently released HERO8 Black note how HyperSmooth had already “eliminated the need for using a motorized gimbal,” and how the electronic image stabilization of HyperSmooth 2.0 was “unfathomably good.” Ex. 2042 (CX-1388) at 3.

D. Long-Felt but Unmet Need

Before HyperSmooth, users of action cameras struggled to capture stable footage during high-vibration activities like mountain biking, hiking, or

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surfing. Ex. 2018, ¶¶ 215-217. Mechanical gimbals were often used but were bulky, fragile, and poorly suited to these dynamic conditions. *Id.* The '840 patent's digital stabilization filled this long-felt need. *Id.* As the Federal Circuit has recognized, solving a long-felt but unmet need supports a finding of non-obviousness. *See Tec Air, Inc. v. Denso Mfg. Michigan Inc.*, 192 F.3d 1353, 1360 (Fed. Cir. 1999).

According to GoPro's Mr. Lema, HyperSmooth was a "shock to the market." Ex. 2024 at ¶ 10. Public reaction was "one of disbelief"—some users assumed GoPro had faked footage using mechanical stabilizers. But once they tried the product, "the response was overwhelmingly positive." *Id.* at ¶ 12.

These outcomes reflect how HyperSmooth filled a long-felt need—further demonstrating the non-obviousness of the claimed inventions. Ex. 2018, ¶¶ 215-218.

E. Failure of Others

GoPro was not the only camera maker seeking to perfect digital image stabilization in 2018. *Id.*, ¶¶ 218-219. Some of the world's greatest technology leaders, including Sony, Google, Samsung, and Apple, were all intently pursuing their own solutions. Many of these approaches involved hybrid

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electronic image stabilization (“EIS”) and optical image stabilization (“OIS”) solutions—as disclosed in Shi, a Google patent, Ex. 1006 at 1:36-44 and Zhou (U.S. Patent No. 9,674,438) at 1:34-45, an Apple patent—which were widely believed to be necessary given the computational requirements of pure EIS solutions and the limitations of mobile devices. As reflected in GoPro’s

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[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED] The

failure of others in the industry to achieve HyperSmooth-level results,

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particularly in a software-only solution (Ex. 2018, ¶¶ 218-219), is strong evidence of non-obviousness. *See Advanced Display Sys, Inc. v. Kent State Univ.*, 212 F.3d 1272, 1285 (Fed. Cir. 2000) (suggesting that such evidence may be “determinative” and “virtually irrefutable of nonobviousness”).

F. Unexpected Results

GoPro's system consistently outperformed traditional stabilization techniques, which often failed under rapidly changing motion. Ex. 2018, ¶¶ 220-221. HyperSmooth maintained stabilization where others did not. Ex. 2014 (“GoPro's HyperSmooth image stabilization is the best we've seen on any action camera”); Ex. 2024 at ¶ 11 (HyperSmooth was a “shock to the market”).

These unexpected results further reinforce the non-obviousness of the '840 patent. Ex. 2018, ¶¶ 220-221.

G. Copying by Competitors

Copying by competitors is a strong indicator of non-obviousness. *See Liqwd, Inc. v. L'Oreal USA, Inc.*, 941 F.3d 1133, 1137 (Fed. Cir. 2019). In this case, Insta360, a direct competitor copied GoPro's HyperSmooth technology, further highlighting the innovative and valuable nature of the '894 Patent. Ex. 2006 (Complaint). Importantly, “the copying inquiry involves a

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comparison of the competitor's product with the allegedly copied product, rather than the patent's claims." *Medtronic, Inc. v. Teleflex Innovations S.a.r.l.*, 70 F.4th 1331, 1340 (Fed. Cir. 2023). Copying can be established by circumstantial evidence such as access to and development of a substantial similar product. *Id.*

Here, Insta360 has repeatedly sought to copy GoPro's patented HyperSmooth features. Ex. 2018, ¶¶ 222-224. Beginning in 2021, Insta360 began releasing its own version of "in-camera" electronic image stabilization technology that relied upon look-ahead smoothing, optimization of the smooth camera trajectory path, and specialized tunable parameters to control the strength of smoothing. Ex. 2048 (Insta360 Speeds Up Workflow with New 360 Reframing Tool, Better Stabilization & Quick Reader). [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

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[REDACTED]

These secondary considerations—commercial success, industry praise, long-felt need, unexpected results, and copying— confirm that the '840 patent's inventions were not obvious. Ex. 2018, ¶¶ 166-224. HyperSmooth revolutionized the action camera market, drove demand, earned recognition, and prompted imitation. The claims should be upheld.

XV. CONCLUSION

For the foregoing reasons, Patent Owner respectfully submits that the Board should uphold the challenged claims.

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Patent Owner's Response
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CERTIFICATE OF LENGTH (37 C.F.R. §§ 42.24)

The undersigned hereby certifies that, according to the word-processing system used to prepare the foregoing document, this document has 13,443 words and thus complies with the applicable word limit.

Date: April 19, 2025

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CERTIFICATE OF SERVICE (37 C.F.R. §§ 42.6(E), 42.105(A))

The undersigned hereby certifies that the foregoing document was served in its entirety on April 19, 2025 upon the following parties via Electronic Mail:

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