

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AXON ENTERPRISE, INC., DEDRONE HOLDINGS, INC., and
SKYDIO, INC.

Petitioner,

v.

AIRSPACE DEFENSE, INC.,
Patent Owner.

IPR2025-00629
Patent 10,514,711 B2

Before MICHAEL R. ZECHER, BARRY L. GROSSMAN, and
SCOTT C. MOORE, *Administrative Patent Judges*.

MOORE, *Administrative Patent Judge*.

JUDGMENT

Final Written Decision

Determining Some Challenged Claims Unpatentable

Granting in Part Patent Owner's

Revised Non-Contingent-in-Part Motion to Amend

35 U.S.C. § 318(a)

I. INTRODUCTION

Axon Enterprise, Inc., Dedrone Holdings, Inc., and Skydio, Inc. (“Petitioner”) filed a Petition (Paper 1, “Pet.”) challenging the patentability of claims 1–20 of U.S. Patent No. 10,514,711 B2 (Ex. 1001, “the ’711 Patent”). We issued an Institution Decision (Paper 16) instituting an *inter partes* review as to all challenged claims based on all grounds raised in the Petition.

Airspace Defense, Inc. (“Patent Owner”) filed a response to the Petition (Paper 20, “PO Resp.”). Petitioner filed a reply to Patent Owner’s Response (Paper 28, “Pet. Reply”). Patent Owner filed a sur-reply to Petitioner’s Reply (Paper 42, “PO Sur-reply”).

In parallel with the above-noted filings, Patent Owner filed an initial contingent-in-part and non-contingent-in-part motion to amend (Paper 21), and Petitioner filed an opposition to the initial motion to amend (Paper 27). We issued Preliminary Guidance (Paper 30) concerning the initial motion to amend. Following the Preliminary Guidance, Patent Owner filed a revised, contingent-in-part and non-contingent-in-part motion to amend (Paper 35, “Motion” or “MTA”), and Petitioner filed an opposition to the Motion (Paper 46, “MTA Opposition” or “MTA Opp.”). Patent Owner filed a reply to the MTA Opposition (Paper 48, “MTA Reply”), and Petitioner filed a sur-reply to the MTA Reply (Paper 50, “MTA Sur-reply”).

An oral hearing was held on August 25, 2026, for which the transcript was entered into the record (Paper 58).

We have jurisdiction under 35 U.S.C. § 6. This Final Written Decision, issued pursuant to 35 U.S.C. § 318(a), addresses issues raised in the Petition and the Motion, and in the related briefing submitted during the trial in this *inter partes* review.

The Motion is contingent with respect to originally challenged claim 12 (MTA 1), and we thus consider the grounds Petitioner asserted in the Petition with respect to original claim 12. The Motion expressly requests to cancel original claims 5–7 (*id.*), and we grant this request. Further, the Motion is non-contingent with respect to originally challenged claims 1–4, 8–11, and 13–20. *Id.* We treat these non-contingent parts of the Motion as a request to cancel original claims 1–4, 8–11, and 13–20. *See Lectrosonics, Inc. v. Zaxcom, Inc.*, IPR2018-01129, Paper 15, 3 (PTAB Feb. 25, 2019) (precedential) *aff'd* 2002 WL 499848 (Fed. Cir. Feb. 18, 2022) (distinguishing between “[a] request to cancel claims [that] will not be regarded as contingent” and “a request to substitute claims [that] ordinarily will be treated as contingent,” and prescribing that “[a] patent owner should adopt a claim-by-claim approach to specifying the contingency of substitution”). Accordingly, we do not consider the grounds of unpatentability asserted in the Petition for original claims 1–11 and 13–20.

We determine that original claim 12 is not unpatentable because Petitioner has not proven by a preponderance of evidence that this claim would have been obvious. As a result, the Motion is moot as to amending claim 12, and we do not reach corresponding proposed substitute claim 29.

We *grant* the Motion as to amending original claim 20 because Patent Owner has shown compliance with the applicable statutory and regulatory requirements, and because Petitioner has not proven by a preponderance of the evidence that corresponding proposed substitute claim 37 lacks enablement or is indefinite.

We, however, *deny* the Motion as to amending original claims 1–4, 8–11, and 13–19 because Petitioner has proven by a preponderance of the

evidence that corresponding proposed substitute claims 21–28 and 30–36 would have been obvious over the asserted prior art and, therefore, unpatentable.

II. BACKGROUND

A. Real Parties-in-Interest

Petitioner identifies Axon Enterprise, Inc., Dedrone Holdings, Inc., and Skydio, Inc. as the real parties-in-interest. Pet. 1. Patent Owner identifies Airspace Defense, Inc. as the real party-in-interest. Paper 24, 2.

B. Related Matters

The parties inform us that the '711 Patent has been asserted in *Airspace Systems, Inc. v. Dedrone Holdings, Inc.*, No. 1-24-cv-01625 (E.D. Va.). Pet. 1; Paper 24, 2. Patent Owner also informs us of the following related *inter partes* review proceedings: IPR2025-00525 and IPR2025-00530. Paper 24, 2.

C. Applied References

Petitioner relies on the references summarized in the table below.

Name	Reference	Exhibit
Pierce	US 2017/0160751 A1, published June 8, 2017	1005
Kumar	US 2017/0161911 A1, published June 8, 2017	1007
Beard	US 9,769,387 B1, issued Sep. 19, 2017	1009
Laufer	US 2017/0059692 A1, published Mar. 2, 2017	1010
Khan	US 2012/0106800 A1, published May 3, 2012	1021
Hogasten	WO 2017/123477 A1, published July 20, 2017	1022
Malecki	US 2013/0301905 A1, published Nov. 14, 2013	1024
Sahasrabudhe	US 2012/0004844 A1, published Jan. 5, 2012	1025

Ning	US 9,760,806 B1, issued Sep. 12, 2017	1034
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MTA Opp. ii–iv, 10–11.

D. Asserted Grounds

Petitioner asserts that original claim 12 is unpatentable based on the following grounds:

Claim(s) Challenged	35 U.S.C. §¹	Reference(s)/Basis
12	103	Beard, Laufer (Ground 1)
12	103	Pierce, Laufer (Ground 9)
12	103	Pierce, Kumar, Laufer (Ground 10)
12	103	Pierce, Sahasrabudhe, Laufer (Ground 17)
12	103	Pierce, Kumar, Sahasrabudhe, Laufer (Ground 18)

Pet. 7–8.

Petitioner asserts that proposed substitute claims 21–37 are unpatentable based on the following grounds:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
21–37	112	Enablement
21–37	112	Indefiniteness

¹ The Leahy-Smith America Invents Act (“AIA”) included revisions to 35 U.S.C. §§ 102, 103, 112, and 316 that became effective on March 16, 2013. Because the applications from which the ’711 Patent claims priority were all filed after this date, the post-AIA versions of §§ 102, 103, and 112 apply. *See* Ex. 1001, codes (22), (60), (63).

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
21–27, 29, 31–33, 35	103	Beard, Laufer, Pierce, Khan, Kumar (Ground 23)
28	103	Beard, Laufer, Malecki, Pierce, Khan, Kumar (Ground 24)
30	103	Beard, Laufer, Sahasrabudhe, Pierce, Khan, Kumar (Ground 25)
34	103	Beard, Laufer, Hogasten, Pierce, Khan, Kumar (Ground 26)
36	103	Beard, Laufer, Pierce, Ning (Ground 27)
21, 23–26, 32	103	Pierce, Kumar, Khan, Beard (Ground 28)
22, 29, 35	103	Pierce, Kumar, Khan, Beard, Laufer (Ground 29)
34	103	Pierce, Kumar, Khan, Beard, Sahasrabudhe, Hogasten, (Ground 30)
36	103	Pierce, Kumar, Ning, Beard (Ground 31)
21, 23–26, 31–33	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe (Ground 32)
22, 29, 35	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe, Laufer (Ground 33)
34	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe, Hogasten (Ground 34)
36	103	Pierce, Kumar, Sahasrabudhe, Ning (Ground 35)

MTA Opp. 10–11. Patent Owner does not dispute the prior art status of the above references. *See generally* MTA Reply.

E. The '711 Patent

The '711 Patent, titled “Flight Control Using Computer Vision,” relates to controlling the flight of a reference aerial vehicle by, for example, capturing an image, identifying a target in the image, determining the relative location of the target with respect to the reference aerial vehicle, and performing a flight control operation on the reference aerial vehicle based on this relative location. Ex. 1001, codes (54), (57).

The '711 Patent discloses that an Unmanned Aerial Vehicle (UAV) may be used as an interceptor aerial vehicle to monitor and/or capture offending or threatening aerial vehicles. Ex. 1001, 3:3–21. The interceptor aerial vehicle may be configured to “autonomously track and fly to the target UAV using machine vision based on images captured by a camera of the interceptor aerial vehicle.” *Id.* at 3:27–30. In particular, the interceptor aerial vehicle may capture an image, use “deep learning, neural networks, and/or other machine learning techniques” to identify a target aerial vehicle in the captured image, compute a “three-dimensional relative location of the target aerial vehicle” based on the image, and then perform a “flight control operation” to guide the interceptor aerial vehicle towards the target aerial vehicle. *Id.* at 3:31–45.

III. ANALYSIS OF ORIGINAL CLAIM 12

A. Background

Claim 12, and claim 1 from which it depends, are reproduced below, with Petitioner’s designations of claim elements indicated by brackets.

1. [1a] A method of performing a flight control operation of a reference aerial vehicle, comprising:

[1b] receiving an image captured by an image sensor of the reference aerial vehicle;

- [1c] detecting a target in the image including by applying a machine learning model to the image to identify a portion of the image that includes the target;
- [1d] determining a three-dimensional relative location of the target with respect to the reference aerial vehicle based on the image including by determining a distance to the target based at least in part on a size of the target detected within the image; and
- [1e] performing the flight control operation based on the three-dimensional relative location of the target with respect to the reference aerial vehicle, wherein performing the flight control operation includes determining a speed adjustment factor based on a magnitude of deviation of a direction of the three-dimensional relative location with respect to a current flight direction of the reference aerial vehicle.

12. The method of claim 1, further comprising:

- receiving a geographical location associated with the target detected at least in part using a ground-based sensor;
- autonomously navigating the reference aerial vehicle towards the received geographical location; and
- determining to allow image-based navigation.

B. Obviousness under 35 U.S.C. § 103

An invention is not patentable under 35 U.S.C. § 103 “if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains.” The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of skill in the art; and, (4) where in evidence, so-called secondary considerations,

including commercial success, long-felt but unsolved needs, and failure of others.² *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

C. Level of Ordinary Skill in the Art

In our Institution Decision, we adopted Petitioner’s proposal that one of ordinary skill in the art would have had the following qualifications:

[E]ither (1) a Bachelor of Science in Mechanical Engineering, Electrical Engineering, Aerospace engineering, or an equivalent field, as well as at least 2 years of academic or industry experience in the aerospace or avionics fields, or (2) at least four years of experience in any of the above industries.

Paper 16, 6–7 (citing Pet. 8; Ex. 1003 ¶¶ 50–54). Patent Owner has not disputed this formulation; thus, we adopt it for purposes of this Decision. See Paper 16, 11 n.10.

D. Claim Construction

We interpret claims in the same manner used “in a civil action under 35 U.S.C. § 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of

² Patent Owner does not allege that any such secondary considerations are present in this case. Patent Owner previously argued that it received funding from the U.S. Army because of the invention’s innovative characteristics (*see* PO Resp. 7–8), but Patent Owner never argued that this funding constituted objective indicia of non-obviousness (*see id.*), and Patent Owner subsequently withdrew the exhibit upon which this argument was based and withdrew this argument (*see* Paper 57). Patent Owner also asserted that Patent Owner’s unmanned aerial vehicle (UAV) was “accepted for inclusion in the Smithsonian National Air and Space Museum,” but Patent Owner never alleged that this acceptance constituted objective indicia of non-obviousness, and never attempted to demonstrate a nexus between this selection and any challenged claim. *See* PO Resp. 8. Patent Owner also does not make secondary considerations arguments regarding any of the proposed substitute claims. *See generally* MTA Reply.

ordinary skill in the art and the prosecution history pertaining to the patent.” 37 C.F.R. § 42.100(b). When applying that standard, we interpret the claim language as it would have been understood by one of ordinary skill in the art in light of the specification. *Wasica Fin. GmbH v. Cont’l Auto. Sys., Inc.*, 853 F.3d 1272, 1279–80 (Fed. Cir. 2017). Absent lexicography or disclaimer, we generally give claim terms their ordinary and customary meaning as understood by an ordinarily skilled artisan. *See Phillips v. AWH Corp.*, 415 F.3d 1303, 1312–13 (Fed. Cir. 2005) (en banc). Only terms that are in controversy need to be construed, and then only to the extent necessary to resolve the controversy. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017).

The parties dispute the meaning of the following limitation in claim 12: “autonomously navigating the reference aerial vehicle towards the received geographic location” (hereinafter, the “Autonomous Navigation” limitation). PO Resp. 5, 10–12. Patent Owner contends that the Autonomous Navigation limitation requires the aerial vehicle to “navigate without human guidance and without guidance from another ground-based and/or aerial system.” *Id.* at 5. Petitioner, in contrast, argues that the Autonomous Navigation limitation merely requires that navigation be accomplished “without human control.” Reply 10. Petitioner explicitly asserts that, under its proposed construction, the recited “reference aerial vehicle” could navigate autonomously as required by claim 12 even if all of that vehicle’s movements were controlled by a ground station, so long as the ground station operated without human control. *Id.* at 11.

Because our task is to determine the meaning this term would have to “one of ordinary skill in the art in light of the specification,” *see Wasica*, 853

F.3d at 1279–80, we begin our analysis with the Specification of the '711 Patent. The Specification indicates when a UAV (such as the recited “reference aerial vehicle”) navigates autonomously, it flies without manual control, and can, for example, track and fly to a target using information captured onboard the vehicle itself. *See* Ex. 1001, 3:24–28 (“[I]t may not be desirable to manually control the interceptor aerial vehicle to follow the target UAV. In some embodiments, the interceptor aerial vehicle is able to autonomously track and fly to the target UAV using machine vision based on images captured by a camera of the interceptor aerial vehicle.”).

The Specification also indicates that “autonomous” means more than just “automatic flight,” and clarifies that autonomous navigation occurs when a UAV that previously received a target location from an external source subsequently turns and flies itself towards the received location. *See, e.g., id.* at 4:15–17 (disclosing that the detected location of a target may be provided to an interceptor “to allow it to automatically and autonomously fly toward the direction of the detected location”); 15:64–16:3 (automatic and autonomous navigation occurs when an interceptor’s navigation component and/or flight controller receive the location of a target, and adjust the interceptor “to turn and fly towards the received location . . . based on the received location”); 16:49–60 (“For example, a flight direction and/or speed of an interceptor aerial vehicle are automatically and autonomously adjusted based on a location and size of the target within the captured image. . . . This allows the flight path of the interceptor aerial vehicle to be dynamically adjusted to track and follow a moving target.”).

The Specification additionally discloses that, when a UAV flies, the UAV’s central processing unit (CPU) “may be configured to perform one or

more flight decisions,” for example, “the CPU may provide one or more flight commands,” such as “a specified speed for the UAV, a specified height for the UAV, [or] or a particular flight path for the UAV.” Ex. 1001, 9:38–43. The UAV’s flight control module responds to these flight control commands by “control[ling] the motors associated with the UAV . . . so that the [UAV] flies in a manner that is consistent with the flight commands.” *Id.* at 9:43–47.

The Specification then draws a clear distinction between autonomous flight, and flight based on control instructions from a remote command center. *See id.* at 9:47–51 (“In some embodiments, the CPU is configured to receive flight instructions from a remote command center. In other embodiments, the CPU is configured to autonomously fly the UAV.”). It is apparent from this disclosure that a UAV is not “autonomously navigating” if that vehicle’s flight path is being controlled by flight instructions received from a remote command center.

These portions of the Specification are consistent with Patent Owner’s position that “autonomously navigating” requires the UAV to “navigate without human guidance and without guidance from another ground-based and/or aerial system.” PO Resp. 5. They are also consistent with the extrinsic dictionary definitions cited by Patent Owner, which define “autonomous” as “undertaken or carried on without outside control” or “independent and having the power to make your own decisions.” *See* PO Resp. 11 (emphasis omitted).

Petitioner argues that “autonomously navigating” encompasses situations in which a UAV operates under the control of a ground station by pointing to language from the Specification discussing the disadvantages of

manual control by a human operator. *See* Reply 10 (citing Ex. 1001, 1:27–34, 3:24–26). But the cited disclosures merely describe disadvantages of manual control; they do not purport to define or describe “autonomous” navigation. *See* Ex. 1001, 1:27–34, 3:24–26). Petitioner additionally argues that the ’711 Patent describes embodiments in which a separate ground station provides commands to the aerial vehicle. *See* Reply 11. Petitioner is correct, but as discussed above, the Specification also distinguishes those embodiments from the separate embodiments in which the UAV flies autonomously. *See* Ex. 1001, 9:47–51 (“In some embodiments, the CPU is configured to receive flight instructions from a remote command center. In other embodiments, the CPU is configured to autonomously fly the UAV.”). Petitioner additionally cites extrinsic dictionary definition evidence defining “autonomous” in terms of the lack of human control or intervention. *See* Reply 11. But this extrinsic evidence is not inconsistent with Patent Owner’s proposed construction, and does not overcome the clear language of the Specification distinguishing between systems in which the UAV receives flight instructions from a remote command system, and systems in which the UAV flies autonomously. Ex. 1001, 9:47–51.

We find Patent Owner’s arguments supporting its proposed construction to be more persuasive because they are consistent with the Specification, but provide some additional clarity below. *See* Ex. 2025 ¶¶ 84–87; PO Sur-reply, 1–6. Consistent with Patent Owner’s position, we construe “autonomously navigating the reference aerial vehicle towards the received geographic location” as meaning that the flight commands or instructions that control the reference aerial vehicle’s flight path are generated onboard the vehicle itself, and are not received from a remote

source. *See* Ex. 1001, 9:47–51; Ex. 2025 ¶¶ 84–87; PO Sur-reply, 1–6. We further clarify that a reference aerial vehicle may autonomously navigate to a received geographic location (e.g., a target location) so long as the vehicle determines its own flight path. *See* Ex. 1001, 9:38–51, 10:49–60. However, a reference aerial vehicle is not “autonomously navigating” towards a received geographic location if the vehicle’s flight path is being controlled by commands received from a remote location. *See id.* at 9:47–51; Ex. 2025 ¶¶ 84–87; PO Sur-reply, 1–6.

E. Obviousness of Claim 12 Based on Beard and Laufer (Ground 1)

Petitioner contends that claim 12 is unpatentable as obvious over Beard and Laufer. We begin with brief overviews of these references.

1. Overview of Beard (Ex. 1009)

Beard relates to “[a]n action camera system for an unmanned aerial vehicle (UAV),” where image processing can determine a desired orientation of a selected target to the UAV, and “the UAV can track the target and provide streaming video images from the desired orientation.” Ex. 1009, code (57). In an embodiment, Beard discloses that the action camera system, including an image processor, is “incorporated aboard a UAV.” *Id.* at 3:9–12, 4:14–15. The action camera system identifies potential target objects “via bounding boxes,” and can “determine a relative orientation of potential target objects [] based on the orientation of bounding boxes.” *Id.* at 3:64–4:4.

2. Overview of Laufer (Ex. 1010)

Laufer relates to systems and methods for drone interdiction, and discloses detecting a target aircraft, generating an interception location, and directing an interceptor aircraft to the interception location to immobilize the target aircraft. Ex. 1010, code (57). For determining whether a target is a

threat, Laufer discloses using image or video data from a camera on the interceptor aircraft and applying machine learning algorithms to classify the target. *Id.* ¶ 31. For navigating to an interception location, Laufer discloses using autopilot command module 440 of central controller 115 to generate autopilot aircraft commands based on an interception location, where central controller 115 can be connected to the interceptor aircraft through a wireless connection. *Id.* ¶¶ 30, 40, Fig. 4.

3. *Obviousness over Beard and Laufer*

Petitioner contends that “Laufer teaches that doppler radar signals generated by ground-based doppler radars (e.g., the “Laufer Wind MD-12”) are used to determine, and thereby receive, an “interception location” where [Beard’s] UAV 100 and the target will intercept.” Pet. 34. Petitioner alleges that one of ordinary skill in the art would have combined Beard and Laufer such that Beard’s “UAV 100 is brought to within an imaging range of the target using [Laufer’s] interception location and autopilot commands.” *Id.* at 34. Petitioner contends that this type of navigation according to Laufer’s autopilot commands would constitute “autonomously navigating the reference aerial vehicle towards the received geographical location,” as recited by claim 12. *Id.* (citing Ex. 1010 ¶¶ 22–31, 38–40, Fig. 4) (emphasis omitted).

Patent Owner argues that, even if one of ordinary skill in the art would have had reason to combine Beard and Laufer in the manner proposed by Petitioner, the combination would not satisfy the Autonomous Navigation limitation required by claim 12 because Laufer’s autopilot commands are generated by and transmitted from a remote command center (i.e., Laufer’s central controller 115). PO Resp. 15–16. In its Reply, Petitioner does not dispute that Laufer’s autopilot commands are generated by Laufer’s central

controller 115, which is remote from the aircraft being controlled. *See* Reply 13–17. Petitioner asserts, however, that the combination still satisfies the Autonomous Navigation limitation because these autopilot commands are generated without human input. *See id.*

Based on the complete trial record, Patent Owner’s arguments are persuasive. *See* PO Resp. 15–16; PO Sur-reply 42, 1–6; Ex. 2025 ¶¶ 84–87. The flight of Beard’s UAV 100 under the control of Laufer’s autopilot commands does not satisfy the Autonomous Navigation limitation of claim 12, as we have construed that limitation, because Laufer’s autopilot commands are generated at a location that is remote from UAV 100 (Laufer’s central controller 115.) *See, e.g.*, Ex. 1010 ¶ 40 (“Central controller 115 uses autopilot command module 440 to generate autopilot aircraft commands”), ¶¶ 26, 30 (clarifying that central controller 115 and the controlled interceptor aircraft are separate devices that may communicate through a “wireless connection”), Fig. 4 (depicting “aircraft control commands 475” being generated externally from the depicted “Interceptor Aircraft”); *see also* Ex. 2025 ¶¶ 95–95. Petitioner never disputes that, in the proposed combination, Laufer’s central controller 115 would remain external to Beard’s UAV 100. *See* Reply 13–17. Instead, Petitioner relies on its proposed construction of the Autonomous Navigation limitation, which would have encompassed such an arrangement. *See id.* Our construction of the Autonomous Navigation limitation, which did not adopt Petitioner’s claim construction position, is dispositive of Petitioner’s argument. We thus determine that Petitioner has not shown by a preponderance of the evidence that claim 12 would have been obvious over Beard and Laufer.

F. Remaining Grounds Challenging Claim 12 (Grounds 9, 10, 17, and 18)

In the remaining grounds challenging claim 12, Petitioner similarly relies on autopilot commands supplied to a UAV by Laufer's remote central controller 115 to satisfy the Autonomous Navigation limitation of claim 12. *See* Pet. 70, 80. Accordingly, these grounds fail for similar reasons.

G. Conclusion

For the foregoing reasons, Petitioner has failed to demonstrate by a preponderance of the evidence that original claim 12 of the '711 Patent is unpatentable under 35 U.S.C. § 103.

IV. ANALYSIS OF PROPOSED SUBSTITUTE
CLAIMS 21–28 AND 30–37

Patent Owner's Motion proposes to add substitute claims 21–37 to the '711 Patent. As discussed above, Patent Owner's request to amend the '711 patent to replace original claim 12 with proposed substitute claim 29 was contingent on us determining that original claim 12 is unpatentable. Because we have *not* found claim 12 to be unpatentable, the Motion is moot with respect to proposed substitute claim 29. Accordingly, only proposed substitute claims 21–28 and 30–37 remain for our consideration.

For the reasons discussed below, we determine that Petitioner has not proven by a preponderance of the evidence that proposed substitute claim 37 lacks enablement or is indefinite. Because Petitioner does not challenge claim 37 on any other basis, we grant the Motion as to proposed substitute claim 37. In contrast, we determine that Petitioner has proven by a preponderance of the evidence that proposed substitute claims 21–28 and 30–36 would have been obvious over the asserted prior art and, therefore,

unpatentable under 35 U.S.C. § 103. We, therefore, deny the Motion as to these claims.

A. The Independent Proposed Substitute Claims

Independent proposed substitute claims 21, 36, and 37 are reproduced below, with underlined language showing subject matter added to the corresponding original claims, and double brackets indicating removed language. Patent Owner's designations of claim elements are indicated by single brackets.

[[1]]21.[pre] A method of performing a flight control operation of a reference aerial vehicle, comprising:

[21.a] receiving at a processor at the reference aerial vehicle an image captured by an image sensor of the reference aerial vehicle;

[21.b] detecting at the reference aerial vehicle a target in the image including by applying at the reference aerial vehicle a machine learning model to the image, to identify a bounding box outlining a portion of the image that includes detected features of the target, and to identify a classification of the detected target;

[21.c] determining at the reference aerial vehicle a three-dimensional relative location of the target with respect to the reference aerial vehicle based on the image including by determining a distance to the target based at least in part on a size of the bounding box of the target detected within the image and on a physical size corresponding to the classification of the target detected within the image; and

[21.d] performing at the reference aerial vehicle the flight control operation based on the three-dimensional relative location of the target with respect to the reference aerial vehicle, wherein performing the flight control operation includes determining a first speed adjustment factor based on a magnitude of deviation of a direction of the

three-dimensional relative location with respect to a current flight direction of the reference aerial vehicle.

[[19]]36.[pre] A reference aerial vehicle, comprising:

[36.a] an image sensor configured to capture an image;

[36.b1] a processor configured to: detect at the reference aerial vehicle a target in the image; and

[36.b2] determine at the reference aerial vehicle a three-dimensional relative location of the target with respect to the reference aerial vehicle based on the image; and

[36.c] a flight controller configured to perform a flight control operation based on the three-dimensional relative location of the target with respect to the reference aerial vehicle, wherein the flight controller is configured to perform the flight control operation including by being configured to determine a speed adjustment factor based on a magnitude of deviation of a direction of the three-dimensional relative location with respect to a current flight direction of the reference aerial vehicle[[.]],

[36.d] wherein the detecting of the target in the image is performed by applying at the reference aerial vehicle a first neural network at a first robustness and a first compute cost, and the determining of the three-dimensional relative location of the target in the image comprises incrementally predicting the location of the target in the image by applying at the reference aerial vehicle a second neural network at a second robustness and a second compute cost, the first robustness and the first compute cost being greater, respectively, than the second robustness and the second compute cost.

[[20]]37.[pre] A computer program product for performing a flight control operation of a reference aerial vehicle, the computer program product being embodied in a non-transitory computer readable storage medium housed in

a reference aerial vehicle and comprising computer instructions for:

- [37.a] receiving a current image captured by an image sensor of the reference aerial vehicle;
- [37.b] detecting at the reference aerial vehicle a target in the current image including by applying a machine learning model to the current image to identify a portion of the current image that includes the target;
- [37.c] determining at the reference aerial vehicle a three-dimensional relative location of the target with respect to the reference aerial vehicle based on the current image including by determining a distance to the target based at least in part on a size of the target detected within the current image; and
- [37.d] performing at the reference aerial vehicle the flight control operation based on the three-dimensional relative location of the target with respect to the reference aerial vehicle, wherein performing the flight control operation includes determining a speed adjustment factor based on a magnitude of deviation of a direction of the three-dimensional relative location with respect to a current flight direction of the reference aerial vehicle[.],
- [37.e1] wherein a first neural network or a second neural network was applied to an immediately preceding image, and the detecting of the target in the current image further comprises making a selection, from between the first and the second neural networks, of only one of the first and the second neural networks, based on a confidence level for a detection of the target in the current image;
- [37.e2] wherein the first neural network has a first robustness and a first refresh rate, and the second neural network has a second robustness and a second refresh rate, the first robustness being greater than the second robustness and the first refresh rate being less than the second refresh rate, and
- [37.e3] when the second neural network was selected and applied to the immediately preceding image, making the

selection comprises: (i) selecting and applying the first neural network to the current image when the confidence level is below a first threshold of a range defined by the first threshold and a second threshold greater than or equal to the first threshold, and otherwise (ii) selecting and applying the second neural network to the current image, and

[37.e4] when the first neural network was selected and applied to the immediately preceding image, making the selection comprises: (i) selecting and applying the second neural network to the current image when the confidence level is above the second threshold, and otherwise (ii) selecting and applying the first neural network to the current image.

MTA, Claims App.

B. Legal Standard

Petitioner bears the burden of persuasion to show that any proposed substitute claim is unpatentable by a preponderance of the evidence.

Lectrosonics, IPR2018-01129, Paper 15; 37 C.F.R. § 42.121(d)(2). “Before considering the patentability of any substitute claims, however, the Board first must determine whether the motion to amend meets the statutory and regulatory requirements set forth in 35 U.S.C. § 316(d) and 37 C.F.R. § 42.121.” *Lectrosonics*, Paper 15 at 4–8. Patent Owner bears the burden of persuasion to show by a preponderance of the evidence that the motion to amend complies with these requirements. 37 C.F.R. § 42.121(d)(1).

Specifically, a patent owner must make an initial showing to demonstrate the following: (1) that a “reasonable number of substitute claims” have been proposed for each challenged claim (35 U.S.C. § 316(d)(1)(B)); (2) that the proposed amendments respond to a ground of unpatentability involved in the trial (37 C.F.R. § 42.121(a)(2)(i)); and (3) the amendments do not seek to

enlarge the scope of the claims and do not introduce new matter (35 U.S.C. § 316(d)(3)). *Lectrosonics*, Paper 15 at 4–8.

C. Compliance with the Legal Requirements Set Forth in 35 U.S.C. § 316(d) and 37 C.F.R. § 42.121

Patent Owner bears the burden to ensure that its Motion complies with the legal requirements set forth in 35 U.S.C. § 316(d) and 37 C.F.R. § 42.121. *Lectrosonics*, Paper 15 at 4, 7–8. For the reasons that follow, we determine that Patent Owner has satisfied this burden.

1. Proposal of a Reasonable Number of Substitute Claims

A motion to amend must “propose a reasonable number of substitute claims.” 35 U.S.C. § 316(d)(1)(B); *see also* 37 C.F.R. § 42.121(a)(3) (“A motion to amend may cancel a challenged claim or propose a reasonable number of substitute claims.”). “There is a rebuttable presumption that a reasonable number of substitute claims per challenged claim is one (1) substitute claim.” *Lectrosonics*, IPR2018-01129, Paper 15 at 4; *see also* 37 C.F.R. § 42.121(a)(3). Patent Owner has shown it proposes a reasonable number of substitute claims by proposing a single substitute claim for each of challenged claims 1–4, 8–11, and 13–20. MTA 1–2, Claims App. Petitioner does not argue otherwise. *See generally* MTA Opp.

We determine that Patent Owner meets this requirement.

2. Amendments Respond to a Ground of Unpatentability

“A motion to amend may be denied where ... [t]he amendment does not respond to a ground of unpatentability involved in the trial.” 37 C.F.R. § 42.121(a)(2)(i). Patent Owner has responded to the grounds of unpatentability involved in this proceeding by amending the claims in response to the Petition’s asserted prior art. *See* MTA 2, 25, Claims App. Petitioner does not argue otherwise. *See generally* MTA Opp.

We determine that Patent Owner meets this requirement.

3. *No Enlargement of the Scope of the Claims*

An amendment may not seek to enlarge the scope of the claims of the patent. 35 U.S.C. § 316(d)(3); 37 C.F.R. §§ 42.121(b)(1)–(b)(2). Patent Owner asserts that the amendments in the Motion do not enlarge the scope of the claims of the patent because each proposed substitute claim “retains all of the limitations of the corresponding challenged claim, and each proposed independent substitute claim adds further limitations.” *See* MTA 2, Claims App. Petitioner does not argue otherwise. *See generally* MTA Opp.

We determine that Patent Owner meets this requirement.

4. *No Introduction of New Matter*

An amendment may not introduce new matter. 35 U.S.C. § 316(d)(3); 37 C.F.R. §§ 42.121(b)(1)–(b)(2). New subject matter is any addition to the claims that lacks sufficient written description support in the subject patent’s original disclosure. *See TurboCare Div. of Demag Delaval Turbomach. Corp. v. Gen. Elec. Co.*, 264 F.3d 1111, 1118 (Fed. Cir. 2001) (“When [an] applicant adds a claim ... , the new claim[] ... must find support in the original specification.”). Patent Owner is required to show written description support in “the original disclosure of the patent for each claim that is ... amended,” and in “an earlier-filed disclosure for each claim for which benefit of the filing date of the earlier filed disclosure is sought.” 37 C.F.R. §§ 42.121(b)(1)–(b)(2).

The test for satisfying the written description requirement “is whether the disclosure of the application relied upon reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of the filing date.” *Ariad Pharms., Inc. v. Eli Lilly & Co.*, 598 F.3d

1336, 1351 (Fed. Cir. 2010) (en banc). In its Motion, Patent Owner provides citations to U.S. Patent Application No. 16/142,452 (Ex. 2019) (“the ’452 application”), from which the ’711 Patent issued. *See* MTA 2–25; Ex. 1001, code (21).

a) Proposed Substitute Claim 37

Petitioner contends that the ’452 application lacks written description support for limitations [37.e1], [37.e3], and [37.e4] because these limitations “require image-by-image decision-making based on the *immediately preceding image* and the *current image*,” and the ’452 application only “describes switching between processing scheme groups, but not on a per-image basis where neural network (NN) choice for the *current image* depends on the NN applied to an *immediately preceding image*.” MTA Opp. 1 (emphasis in original) (citing Ex. 2019 ¶¶ 141–152; Ex. 1039 ¶¶ 72–76). Patent Owner argues in response that the ’452 application discloses selecting a neural network for processing a current image, where “this trade off occurs on a per frame (i.e., image) basis.” MTA Reply 1 (citing Ex. 2019 ¶ 109). In particular, Patent Owner asserts that the ’452 application describes using a confidence number produced in processing a frame for selecting the best neural network for the next frame to be processed. *Id.* (citing Ex. 2019 ¶¶ 141, 145–152). Petitioner replies by characterizing as “bare attorney argument” Patent Owner’s assertion that “a confidence ‘informs that in each frame/image, a target is detected and a corresponding confidence number is used to select the best NN’ for the next frame.” MTA Sur-reply 1.

Having considered the evidence and argument cited by both parties, we determine there is sufficient written description support for the disputed portions of limitations [37.e1], [37.e3], and [37.e4]. The ’452 application discloses selecting between groups of processing schemes (e.g., algorithms)

depending on a confidence level, where the groups are, for example: high cost, high robustness algorithms; medium cost, medium robustness algorithms; and low cost, low robustness algorithms. *See* Ex. 2019 ¶¶ 146–147. These schemes or algorithms may be neural networks. *See, e.g., id.* ¶ 50 (including neural network as a type of algorithm); *see also id.* ¶¶ 109–110); *see generally* MTA Opp 1 (not disputing that schemes may be neural networks). Specifically, the ’452 application describes “algorithms that process video frames of one or more video data streams,” and “produce a prediction of objects within the video f[r]ame, as well as a confidence number that is a measure of quality for that prediction.” *Id.* ¶ 141.

The ’452 application also discloses the concept of switching between neural networks based on confidence levels. In particular, the ’452 application discloses that a “process cycles through the processing schemes to produce a detection of an object,” for example, where “if the confidence number is higher than an activation number, an action is performed to stop or change a running group (i) and select or switch to group (ii).” *Id.* ¶ 146. More particularly, “a processing scheme from the group of (i) High cost (low refresh rate), high robustness algorithm[s] can select a cheaper processing scheme from the group of (ii) Medium cost, medium robustness algorithms.” *Id.*

The ’452 application additionally discloses that schemes or algorithms (e.g., neural networks) are applied to individual video frames, and that the confidence levels that determine which neural network will be applied in the future are also derived from individual video frames. For example, as discussed above, the ’452 application describes that “[t]he processing schemes produce a prediction of objects within the video f[r]ame, as well as

a confidence number that is a measure of quality for *that* prediction.” Ex. 2019 ¶ 141 (emphases added). The ’452 application also describes selecting and applying an individual neural network, rather than only selecting and applying a group of processing schemes. For example, as highlighted above, the ’452 application describes that “*a* processing scheme from the” “High” group “can select *a* cheaper processing scheme from the” “Medium” group. *Id.* ¶ 146 (emphases added). In our view, these disclosures, read together, would reasonably convey to one skilled in the art that the inventor had possession of the disputed subject matter described above. *See Ariad*, 598 F.3d at 1351.

Petitioner also contends that there is no adequate written description support for the thresholds recited in limitations [37.e3] and [37.e4]. Regarding limitation [37.e3], Petitioner contends the ’452 application does not describe “a range defined by two separate thresholds, including separate thresholds that can be *equal*, collapsing the *range* into a single point.” MTA Opp. 1–2 (emphasis in original) (citing Ex. 2019 ¶¶ 146–147; Ex. 1039 ¶ 78–79). Regarding limitation [37.e4], Petitioner contends that the ’452 application does not support “selecting and applying the second neural network ... when the confidence level is above the second threshold,” where the second threshold defines a range in which the second threshold is “greater than or equal to the first threshold” (limitation [37.e3]). *Id.* at 2 (citing Ex. 2019 ¶¶ 112, 116, 146–147; Ex. 1039 ¶¶ 80–81) (emphasis omitted).

In response, Patent Owner points to disclosures in which switching between processing schemes in different groups depends on whether “the confidence is *below low threshold*, falls outside of a range,” or “the

confidence number is higher than an activation number.” MTA Reply 1–2 (emphasis in original) (citing Ex. 2019 ¶¶ 146–147). Patent Owner argues that the “[l]ow threshold’/‘activation number’ are the first/second thresholds, respectively, defining a range,” and that “the range can be a point range, i.e., a single threshold.” *Id.* at 2 (citing Ex. 2019 ¶¶ 112–113, 146–147). Petitioner argues in reply that Patent Owner’s assertion “that ‘the range can be a point range, i.e., a single threshold’” has no written description support in the ’452 application, and that Patent Owner “patches together separate thresholds (‘low threshold’/‘activation number’), but none of those are disclosed as two separate thresholds, that can be equal, defining a range.” MTA Sur-reply 1–2.

Having considered the evidence and arguments of both parties, we are persuaded that there is sufficient written description support for the disputed portions in limitations [37.e3] and [37.e4]. The ’452 application discloses that, “[i]f the confidence is below low threshold, falls outside of a range, or the validation method fails, group (i) processing is performed,” but “[i]f the confidence is determined to be high, then group (iii) algorithms can be applied,” where “group (iii) and group (ii)[] may be similar and selected based on different secondary factors to optimize local computing resources.” Ex. 2019 ¶ 147; *see also id.* ¶¶ 112 (“In response to the performance score of the active processing scheme failing to satisfy a threshold, the method selects another processing scheme to process the video data stream.”), 146 (“[I]f the confidence number is higher than an activation number, an action is performed to stop or change a running group (i) and select or switch to group (ii).”). These disclosures clearly convey the concepts of using either a range of thresholds, or single threshold, to select an algorithm (e.g., a neural

network), and would reasonably convey to one skilled in the art that the inventor had possession of the disputed subject matter described above. *See Ariad*, 598 F.3d at 1351.

As Petitioner points out, proposed substitute claim 37 encompasses a scenario in which first and second thresholds are equal, such that they would collapse into a single point. MTA Opp. 2. Though this scenario is not specifically recited in the '452 application, we find it is nevertheless inherently disclosed. In this regard, we are persuaded by the testimony of Patent Owner's declarant, Dr. Papanikolopoulos, that the disclosed schemes of switching between algorithms are operative if the confidence number (the second threshold) is less than or equal to the activation number (the first threshold), but inoperative if the confidence number is greater than the activation number. *See* Ex. 2036 ¶¶ 88–97. We agree with Dr. Papanikolopoulos that these mathematical limits on thresholds that are inherent in the disclosed schemes would have reasonably conveyed to one skilled in the art that the inventor had possession of recited range “defined by the first threshold and a second threshold greater than or equal to the first threshold.” *See id.* (emphasis omitted); *Ariad*, 598 F.3d at 1352 (noting that “the description requirement does not demand any particular form of disclosure, or that the specification recite the claimed invention *in haec verba*”) (citing *Carnegie Mellon Univ. v. Hoffman-LaRoche Inc.*, 541 F.3d 1115, 1122 (Fed. Cir. 2008); *Lockwood v. American Airlines, Inc.*, 107 F.3d 156, 1571–72 (Fed. Cir. 1997)).

b) Proposed Substitute Claim 24

Petitioner also contends there is no written description support for proposed substitute claim 24, which recites, in relevant part, “identifying a model type of the target based on the classification of the detected target.”

MTA Opp. 2. Petitioner argues that the '452 application “describes classifying by ‘type’ **or** ‘model,’ not identifying ‘type’ *based on* ‘classification.’” *Id.* (emphasis in original) (citing Ex. 2019 ¶¶ 94–95; Ex. 1039 ¶¶ 82–83).

Patent Owner argues that the recitation of “identify a classification” in proposed substitute claim 21 and the recitation of “identifying a model type based on the classification” in dependent proposed substitute claim 24 “are two different kinds of classifications: a coarse-grained one where the target is classified as ‘a UAV’ or ‘not a UAV,’” “and a fine-grained one determining the ‘type, model, class, manufacturer, size, etc.’” MTA Reply 2–3 (citing Ex. 2019 ¶ 94; Ex. 2036 § VII.B.1). Petitioner responds by asserting that the claimed arrangement, in which the model type is identified based on the prior classification, “is unsupported” because the '452 application “discloses a lone classification,” and the combination of steps as claimed “requires obviousness.” MTA Sur-reply 2–3.

Having considered the evidence and arguments of both parties, we are persuaded that there is sufficient written description support for the disputed portion of proposed substitute claim 24. The '452 application discloses that “[t]he output of the image analysis (e.g., output from applying the machine learning model) may include ... a classification of the detected target (e.g., type, model, class, manufacturer, size, etc. of the detected target).” Ex. 2019 ¶ 94. It also discloses that, “[i]n some embodiments, the machine learning model has been trained using different examples of types of aerial vehicles (e.g., different models, types, manufacturers, sizes, etc.) to be able to classify and identify the specific type of the detected target aerial vehicle.” *Id.* ¶ 95. These disclosures would have reasonably conveyed possession of proposed

substitute claim 24’s feature of “identifying a model type of the target based on the classification of the detected target.” In particular, we agree with Patent Owner that proposed substitute claim 24 further limits the classification recited in proposed substitute claim 21. *See* MTA Reply 2–3. This additional limitation is supported by the capability of the described machine learning model to both “classify and identify the specific type of the detected target aerial vehicle.” Ex. 2019 ¶ 95.

c) Proposed Substitute Claim 25

Petitioner contends there is no written description support for proposed substitute claim 25, which recites performing a flight control operation that includes “determining a second speed adjustment factor based on the determined distance to the target,” in addition to “determining a first speed adjustment factor based on a magnitude of deviation of a direction of the three-dimensional relative location [of the target] with respect to a current flight direction of the reference aerial vehicle” as recited in proposed substitute claim 21, from which claim 25 depends. MTA Opp. 2. Petitioner argues that the ’452 application “discloses ‘distance value,’ ‘**distance**’-based factor, or ‘**speed**’-based factor, not first and second speed adjustment factors.” *Id.* (emphasis in original) (citing Ex. 2019 ¶ 97; Ex. 1039 ¶¶ 84–85).

Patent Owner argues in response that the speed adjustment factor described in the ’452 application “can be modified and redefined at different times such that the first factor is provided at one time and the second factor at another.” MTA Reply 3 (citing Ex. 2019 ¶¶ 91, 97; Ex. 2036 § VII.B.2). Petitioner asserts in reply that the concept of speed adjustment factors “‘modified and redefined at different times’ and provided at different times is unsupported and erroneous.” MTA Sur-reply 3. Petitioner also asserts

that Patent Owner “leaves unexplained how these factors provided at different times would allow such a *flight control operation*,” and that Patent Owner’s cited portions of the ’452 application “do not disclose determining multiple [speed adjustment factors] for a flight control operation.” *Id.* (emphasis in original) (citing Ex. 2019 ¶¶ 90, 97).

We are persuaded that the ’452 application provides sufficient written description support for the limitation of proposed substitute claim 25. The ’452 application discloses that “[m]odifying the speed and/or acceleration associated with the vector includes adjusting a factor used to control the speed and/or acceleration of the interceptor aerial vehicle based on an amount of direction changed specified by the vector.” Ex. 2019 ¶ 99. Further, the process of which modifying the speed is a part of the flow chart illustrated in Figure 5, and “may be repeated when a target aerial vehicle is detected in an image being continually captured by an interceptor aerial vehicle.” *Id.* ¶ 93, Fig. 5. This disclosure of repeating the speed modification would have conveyed possession of the feature of a “second speed adjustment factor based on the determined distance to the target,” as recited in proposed substitute claim 25, especially given the ’452 application’s description of distance as a component of the vector associated with a speed adjustment factor. *See id.* ¶ 97.

5. Summary

For the reasons discussed above, Patent Owner has satisfied its burden to show that the amendments in the Motion comply with the applicable statutory and regulatory requirements. *See* 35 U.S.C. § 316(d); 37 C.F.R. § 42.121(d)(1); §§ IV.C.1–IV.C.4, *supra*. We now turn to Petitioner’s contentions that the proposed substitute claims are unpatentable.

D. Unpatentability of Proposed Substitute Claims

Petitioner contends that 1) proposed substitute claims 21–28 and 30–37 lack enablement, 2) proposed substitute claims 21–28 and 30–37 are indefinite, and 3) proposed substitute claims 21–28 and 30–36 would have been obvious over several different prior art combinations. MTA Opp. 2–25. Petitioner does not assert that proposed substitute claim 37 would have been obvious. *See id.*

1. Enablement

“The specification must enable the full scope of the invention as defined by its claims,” so that “[t]he more one claims, the more one must enable.” *Amgen Inc. v. Sanofi*, 598 U.S. 594, 610 (2023). But a disclosure is not “necessarily inadequate just because it leaves the skilled artist to engage in some measure of adaptation or testing.” *Id.* at 611. Rather, the “specification may call for a reasonable amount of experimentation to make and use a patented invention,” which “will depend on the nature of the invention and the underlying art.” *Id.* at 612. We determine whether the amount of experimentation required to make and use the claimed invention is undue based upon the factual considerations set forth in *In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988).

Petitioner contends that the claim term “speed adjustment factor” recited in limitations [21.d], [36.c], and [37.d] lacks enablement because it requires undue experimentation. MTA Opp. 2–5. Petitioner discusses the *Wands* factors, arguing that: 1) as to the quantity of experimentation, a skilled artisan “would have been forced to experiment across the entire space of possible functions relating direction deviation to a *speed adjustment factor*, parameter values ..., and saturation strategies (e.g., maximum limit), without any guidance”; 2) there is no direction or guidance on “how to

determine a *speed adjustment factor*”; 3) there are “zero working examples of the *speed adjustment factor*”; 4) “[t]he nature of the invention demands *more* specificity in the specification”; 5) as to the state of the prior art, “[t]he specification points to no prior art teachings of how to determine a *speed adjustment factor* from a magnitude of *directional deviation*”; 6) as to the level of skill in the art, even under Patent Owner’s “elevated [person of ordinary skill in the art (POSITA)] definition,” “[t]he specification delegates invention to the reader”; 7) as to predictability in the art, “[t]he behavior of a *speed adjustment factor* depends on various variables unaddressed by the specification”; and 8) as to claim breadth, the claims cover “any *speed adjustment factor* determined from any *magnitude of deviation* of any *direction of the three-dimensional relative location* with respect to any *current flight direction*.” *Id.* at 3–5 (emphasis in original); *see also* MTA Sur-reply 4–7.

Patent Owner asserts that Petitioner’s own expert, Dr. Singhose, has argued that the claimed “speed adjustment factor” merely “says they are simply going faster/slower depending on whether turning/flying straight.” MTA Reply 3–4 (citing Ex. 1039 ¶ 90). Consistent with this understanding, Patent Owner asserts that the disclosure indicates “[a] ‘*speed adjustment factor*’ is simply a vector element value used to control, i.e., adjust speed.” *Id.* at 4 (emphasis in original) (citing Ex. 2019 ¶ 99). Patent Owner also addresses the *Wands* factors, focusing on the first three factors. *Id.* at 5–7. Specifically, Patent Owner asserts that: 1) “[t]he selection of [speed adjustment factors] is related to the conventional mechanics of UAV flight ... , meaning any necessary experimentation was routine; 2) the Specification describes adjusting a speed adjustment factor by “using a

scalar relating to ‘a directional deviation’ per a ‘bell curve’ or a linear curve”; and 3) the provision of “[s]pecific curves and equation constant values” would not be helpful, given “[t]he choice of a curve/equation constants would depend on the attributes ... of a UAV using them.” *Id.* at 5–6.

We are not persuaded by Petitioner’s contentions, because it appears from the Specification that determining a speed adjustment factor would be straightforward and is well within the skill in the art. For instance, the ’711 Patent discloses that, after an interceptor aerial vehicle detects a target and determines a direction and speed to the target (i.e., a vector), that the speed of the vehicle can be adjusted to account for the “amount of directional change specified by the vector.” Ex. 1001, 19:4–8. Specifically, “when a large directional change is required by the interceptor aerial vehicle to fly towards the target, a slower speed is desirable to allow the direction change to take place at a slower speed over a shorter distance as compared to a faster speed that is desirable to reach the target quicker when no or minor directional change is required.” *Id.* at 19:8–14. The Specification also provides several examples of how to define this relationship between speed and the directional vector. For example, it discloses scaling the speed according to a bell curve, scaling the speed linearly, or scaling the speed as a function of the different directional axes of the vector. *See* Ex. 1001, 19:14–36. Moreover, the Specification includes a number of exemplary illustrations related to determining vectors. *See id.* at 20:12–21:22.

Petitioner’s arguments that the ’711 Patent says “nothing about how to determine a *speed adjustment factor*” and that a skilled artisan would be “forced to experiment across the entire space of possible functions relating

direction deviation to a *speed adjustment factor*” (MTA Opp. 3–4 (emphasis in original)), are out of step with the disclosure, which specifically outlines both the relationship of speed and the directional vector required to intercept the target, and the mathematics required to successfully determine the recited speed adjustment factor. *See* Ex. 1001, 19:4–36, 20:12–22.

Petitioner also contends that the following terms relating to the first and second neural networks lack enablement: “robustness” (limitations [36.d] and [37.e2]); “compute cost” (limitation [36.d]); and “refresh rate” (limitation [37.e2]). MTA Opp. 5–8. Petitioner discusses the *Wands* factors, arguing that: 1) “[t]he quantity of experimentation is substantial,” requiring “an entire research program involving three undefined measurement problems requiring independent resolutions”; 2) the Specification “provides no measurement methodology or baseline against which these qualitative labels [of high, average, or low robustness] are assessed,” there is “zero instruction” on how, in the terms of the Specification, the “compute cost” is “pre-determined, estimated, or calculated,” and “the specification never defines the term [refresh rate], discloses its units, or says how to measure it”; 3) there are “zero working examples of how to determine any of these three values”; 4) as to the nature of the invention, that the claimed “robustness,” “compute cost,” and “refresh rate” have relative values, but the “specification does not define how any of these parameters are determined or measured”; 5) as to the state of the prior art, the Specification “does not disclose a particular methodology for determining” these values for algorithms; 6) as to the level of skill in the art, even under Patent Owner’s “elevated POSITA definition,” these values depend “on undefined metrics that would require undue experimentation”;

7) as to predictability in the art, the “robustness,” “compute cost,” and “refresh rate” “would depend on the hardware [an algorithm] runs on, its inputs, implementation, and the overall system,” but that there is “next to nothing” in the Specification to provide guidance; and 8) as to claim breadth, Petitioner relies on the same argument as for the nature of the invention factor. *Id.* at 6–8; *see also* MTA Sur-reply 7–8.

Patent Owner argues, with respect to “robustness,” “compute cost,” and “refresh rate,” that “a POSITA would have known their meanings and how to determine them, because those terms were well-established in the art.” MTA Reply 4. Specifically, Patent Owner asserts: for “robustness,” “[a] POSITA would have known that robustness can be determined in terms of failure rate or frequency”; for “compute cost,” it “can be expressed as the number of computations, computation time, etc.”; and for “refresh rate,” a skilled artisan would have known that this “is the rate at which new images/frames of a video can be analyzed.” *Id.* (citing Ex. 2019 ¶¶ 145, 146, 150; Ex. 2033, 37:6–16; Ex. 2034, Abstract; Ex. 2043, 7; Ex. 2044, 9; Ex. 2045, 5; Ex. 2046, 2, Figs. 2, 8). Patent Owner addresses the *Wands* factors for the disputed terms. *See id.* at 5–7.

We are not persuaded by Petitioner’s contentions for several reasons. First, it appears that the terms “robustness,” “compute cost,” and “refresh rate” are well known terms of art. *See, e.g.,* MTA Reply 6 (citing various prior art references that employ these terms). The ’711 Patent’s Specification also provides concrete examples of these terms. For example, the Specification discloses that “[r]obustness of each algorithm (e.g. processing scheme) can be compared by measuring a population of inputs that are selected as representative of sample conditions (e.g., real-life data

sets) and prioritized by application requirements.” Ex. 1001, 27:45–48. It also discloses that “[c]osts on all data inputs for the processing schemes can be pre-determined, estimated, or calculated,” where in one example, “a type of algorithm that operates on visual ‘features’ can be dependent on the number of features in the video frame, and its cost estimated based on the number of features,” such that “[a]s the number of features [that] increases the cost can increase dramatically.” *Id.* at 27:36–42. The Specification further indicates that “[r]efresh rate” is inversely related to “compute cost.” *See, e.g., id.* at 27:53–56 (“High cost (low refresh rate)”). As Patent Owner explains, “[a] POSITA would also have known that a low refresh rate means more compute time per image, i.e., high cost.” MTA Reply 4.

In addition, the Specification outlines the qualities embodied in the terms “robustness,” “compute cost,” and “refresh rate.” For example, the Specification describes that “[t]he example implementation can statically assign each processing scheme in a set of processing schemes to a group based on each processing scheme’s determined cost and/or robustness estimations on the selected input group.” Ex. 1001, 27:49–52. This disclosure would aid one skilled in the art in determining which processing schemes should be in each group by clarifying that group (i) (high cost, high robustness) includes “processing schemes that produce an object location estimation independent of historical information,” group (ii) (medium cost, medium robustness) includes those using “a last known location” or “fast validation method,” and group (iii) (low cost, low robustness) includes those using “a known location” or “fast validation method.” *Id.* at 27:53–64. The Specification additionally provides examples of specific known processing schemes that fall within the different groups. *See id.* at 28:40–60.

Petitioner additionally contends that the terms “first threshold,” “second threshold,” and “range” of limitation [37.e3] lack enablement. MTA Opp. 8–9. Petitioner argues that there is “no guidance or examples of a *first threshold* and *second threshold*, defining a *range*, set equal.” *Id.* (emphasis in original). We are not persuaded by Petitioner’s argument because Petitioner offers no explanation or evidence to support this position. *See* MTA Opp. 8–9. On this record, we agree with Patent Owner’s assertion that it would have been within the knowledge of a skilled artisan to set thresholds for a confidence level to indicate which neural networks should be used, based on a desired optimization. *See* MTA Reply 5–6 (addressing *Wands* factors 1–3).

For the foregoing reasons, Petitioner has not proven by a preponderance of the evidence that proposed substitute claims 21, 36, and 37 lack enablement. For the same reasons, we also conclude Petitioner has not proven proposed substitute claims 22–28 and 30–35 (all of which depend from proposed substitute claim 21, and none of which was argued separately), lack enablement.

2. *Indefiniteness*

In *inter partes* review proceedings the Board applies the indefiniteness standard set forth in *Nautilus, Inc. v. Biosig Instruments, Inc.*, 572 U.S. 898 (2014). *See* Memorandum: Approach to Indefiniteness Under 35 U.S.C. § 112 in AIA Post-Grant Proceedings (Jan. 6, 2021)³. Under *Nautilus*, a claim is indefinite if fails to “in form those skilled in the art about the scope of the invention with reasonable certainty.” 572 U.S. at 910.

³ Available at <https://www.uspto.gov/sites/default/files/documents/IndefinitenessMemo.pdf>.

Petitioner contends that the terms “speed adjustment factor,” “robustness,” “compute cost,” and “refresh rate” render proposed substitute claims 21, 36, and 37 indefinite. MTA Opp. 9. Petitioner argues that “[i]t is unclear from the intrinsic record what [these] terms mean.” *Id.* Further Petitioner argues that the terms “robustness,” “compute cost,” and “refresh rate” “have a comparative relationship where some are ‘greater’ or ‘less’ than others,” but “[w]ithout knowing their boundaries/how they are determined or measured, there is no way of comparing them to determine such a relationship.” *Id.* (citing Ex. 1039 ¶¶ 120–128).

Patent Owner argues that the meanings of the disputed terms are clear to a skilled artisan, for example, where “speed adjustment factor” is “a vector element value used to adjust [] speed,” and the neural network parameters “robustness,” “compute cost,” “and “refresh rate” “were well understood and the specification uses them in the same way as in the literature.” MTA Reply 7.

Petitioner asserts in reply that a skilled artisan would not have known the boundaries of the dispute terms, particularly because “it is unclear what [speed adjustment factor] means, including how a [speed adjustment factor] is determined,” and “there are several different ways in which *robustness*, *compute cost*, and *refresh rate* may be measured.” MTA Sur-reply 9 (emphasis in original).

We determine that the disputed terms “speed adjustment factor,” “robustness,” “compute cost,” and “refresh rate” do not render proposed substitute claims 21, 36, and 37 indefinite. The disclosure cited above for enablement (Ex. 1001, 19:7–36, 20:12–21:22 (on “speed adjustment factor”)); *id.* at 27:36–28:60 (on “robustness,” “computer cost,” “refresh

rate”)) would provide helpful guidance to a skilled artisan in ascertaining objective boundaries of these terms with reasonable certainty. Further, the fact that these terms may have different ways of being determined, and so provide varying claim scope, raises an issue of breadth, not indefiniteness. *See ClearOne, Inc. v. Shure Acquisition Holdings, Inc.*, 35 F.4th 1345, 1351 (Fed. Cir. 2022) (“Just because a term is susceptible to more than one meaning does not render it indefinite.”). A term is not unclear merely because it is broad, so long as the boundaries can be ascertained with reasonable certainty. *See BASF Corp. v. Johnson Matthey Inc.*, 875 F.3d 1360, 1367 (Fed. Cir. 2017) (“[T]he inference of indefiniteness simply from the scope finding is legally incorrect: ‘breadth is not indefiniteness.’” (quoting *SmithKline Beecham Corp. v. Apotex Corp.*, 403 F.3d 1331, 1341 (Fed. Cir. 2005))).

Petitioner further contends that limitations [37.e1]–[37.e4] render proposed substitute claim 37 indefinite because they “require network selection for a **current image** is *based on a confidence level for a detection of the target in the current image*,” “[b]ut if no network has yet been applied to the current image, the system cannot have a confidence level *for a detection of the target in the current image*.” MTA Opp. 9 (emphasis in original) (citing Ex. 1039 ¶¶ 129–133).

Patent Owner argues that contrary to Petitioner’s contention, proposed substitute claim 37 “does not require [a neural network (NN)] to be applied to a current frame in order to obtain a confidence level for use in selecting an NN for the current frame.” MTA Reply 8. In other words, claim 37 “does not have a circular dependence.” *Id.* Petitioner responds by asserting that, “[b]y its own terms, the claim relates to detection *in the current image* but if

no NN has yet been applied to the current image, a confidence level for such detection cannot exist, rendering the claim indefinite.” MTA Sur-reply 10 (emphasis in original).

We determine that this disputed language in limitations [37.e1]–[37.e4] does not render proposed substitute claim 37 indefinite. It appears that Petitioner’s argument is based on an unduly narrow reading of proposed substitute claim 37, in which the “confidence level” was generated based on the “detection of the target in the current image.” Limitation [37.e1] recites that, before the “confidence level” is utilized to select between those two neural networks, either “a first neural network or a second neural network was applied to an immediately preceding image.” The Specification discloses that a confidence level would be generated during this application of a neural network to the immediately preceding image. *See* Ex. 1001 27:29–32 (“The processing schemes produce a prediction of objects within the video f[r]ame, as well as a confidence number that is a measure of quality for that prediction.”). A confidence level derived from an immediately preceding image would, because of closeness in time, also represent the confidence for a detection of the target in next image.

The language of proposed substitute claim 37 is also broad enough to encompass embodiments in which the recited confidence level was generated during the application of either the first or second neural network to the immediately preceding image. Indeed, this is the most natural reading of limitations [37.e1]–[37.e4], which specify that the thresholds subsequently applied to the confidence level are selected based upon whether the first or the second neural network was applied to the immediately preceding image. Thus, we are not persuaded by Petitioner’s

contention that [37.e1]–[37.e4] require the confidence level be generated from the current image, rendering these limitations circular and indefinite.

Petitioner additionally contends that limitations [37.e1]–[37.e4] render proposed substitute claim 37 indefinite because the selected neural network is based on which network was applied to the “immediately preceding image,” but the disclosure “never discusses such an image-by-image processing technique” and so there is confusion as to the meaning of “*immediately preceding image*.” MTA Opp. 10 (emphasis in original). We are not persuaded by Petitioner’s contention because, as discussed above, there is sufficient written description support for applying a neural network on a per-image basis. *See* § IV.C.4.a, *supra*; Ex. 1001, 27:26–35 (discussing the use of “algorithms that process video frames of one or more video data streams,” where the algorithms predict objects at the granularity of a single “video f[r]ame”). One of skill in the art would readily understand, with reasonable certainty, that the claim term “immediately preceding image” refers to the immediately preceding video frame or image captured by the image sensor of the reference aerial vehicle.

For the foregoing reasons, we conclude that Petitioner has not proven by a preponderance of the evidence that proposed substitute claims 21, 36, and 37 are indefinite. For the same reasons, Petitioner has not proven that proposed substitute claims 22–28 and 30–35 (all of which depend from proposed substitute claim 21, and none of which was argued separately) are indefinite.

3. *Obviousness Based on Beard, Laufer, Pierce, Khan, and Kumar (Ground 23)*

Brief overviews of Beard and Laufer are provided above. *See* §§ IV.E.1–2, *supra*. Below are brief overviews of Pierce, Khan, and Kumar.

a) Overview of Pierce (Ex. 1005)

Pierce relates to “controlling drone movement for object tracking.” Ex. 1005, code (57). In an embodiment, drone 102 includes a camera for recording images of a moving target. *Id.* ¶ 27. Pierce discloses passing an image through a neural network to produce a bounding box, where “the identity of each object within the bounding box is coherent from one frame to the next.” *Id.* ¶¶ 28, 29. Pierce further discloses using a neural network to determine the position and velocity of the moving target, and tracking the target through multiple image sequences captured by the camera. *Id.* ¶ 32.

b) Overview of Khan (Ex. 1021)

Khan discloses “real-time or near-real-time automatic video classification of vehicle model types in aerial imagery.” Ex. 1021 ¶ 3. Specifically, Kahn describes a UAV with a system “for detecting and classifying types of vehicle models in aerial imagery captured by one or more image capturing devices” through the use of an onboard computing platform 114 for processing video. *Id.* ¶ 39.

c) Overview of Kumar (Ex. 1007)

Kumar discloses “estimating the physical distance and velocities of objects within a sequence of images relative to the camera which took the sequence of images.” Ex. 1007 ¶ 19. Kumar assumes that, “for each image, there is a minimal bounding box around all objects of interest,” where “[s]uch bounding boxes may be output by a neural network detection system.” *Id.*

d) Obviousness of Proposed Substitute Claim 21

(1) Limitations [21.pre], [21.a], and [21.d]

In the Petition, Petitioner asserts that Beard and Laufer teach or suggest each limitation of original claim 1, and that one of ordinary skill in

the art would have had reason to combine Beard and Laufer with a reasonable expectation of success. *See* Pet. 10–27. Patent Owner has not provided arguments disputing these contentions. *See* PO Resp. 10–16 (presenting arguments exclusive to original claim 12); PO Sur-reply 1–24 (same). Accordingly, Patent Owner has waived any arguments responsive to Petitioner’s contentions regarding original claim 1. *See* Paper 17, 10 (“Patent Owner is cautioned that any arguments not raised in the response may be deemed waived.”).

Limitation [21.pre] of proposed substitute claim 21 includes no amendments to the language of original claim 1, and limitations [21.a] and [21.d] are minimally amended to require that the respective steps are performed “at a processor at the reference aerial vehicle,” or simply “at the reference aerial vehicle.” MTA, Claims App. Patent Owner also does not dispute Petitioner’s contentions that the combination of Beard and Laufer would have taught or suggested these identical and minimally amended limitations of proposed substitute claim 21. *See* MTA Reply 9–12.

Accordingly, based on the record before us, and for the reasons explained in the Petition (*see* Pet. 10–27) and the MTA Opposition (*see* MTA Opp. 12, 16 (relying on Beard for the new language in limitations [21.a] and [21.d])), we determine that Beard and Laufer teach limitations [21.pre], [21.a], and [21.d], and that one of ordinary skill in the art would have had reason to combine the teachings of Beard and Laufer with a reasonable expectation of success.

*(2) Limitations [21.b] and [21.c]; Rationale to Combine
Beard and Laufer with Pierce, Khan, and Kumar*

Regarding limitation [21.b], Petitioner contends that Pierce teaches a drone with an “on-board object tracking module” that uses neural networks

to “analyze the images ‘to identify and track the moving target’ and estimate its position and velocity.” MTA Opp. 12 (citing Ex. 1005 ¶¶ 27, 42, 44–46, Figs. 1, 6). Petitioner contends that Khan teaches determining features of a vehicle in images “located within a bounding box surrounding” the vehicle, and using a machine learning model “to determine a classification of vehicle type” based on the features. *Id.* at 12–13 (citing Ex. 1021 ¶ 3, 37–39, 44–63, Figs. 7, 8; Ex. 1039 ¶¶ 149–151). Petitioner also contends that Kumar teaches “‘bounding boxes’ around objects of interest in an image are output by a NN.” *Id.* at 13 (citing Ex. 1007 ¶¶ 2, 19; Ex. 1008 ¶¶ 1, 29; Ex. 1039 ¶ 152).

Regarding limitation [21.c], Petitioner contends that Beard teaches the UAV image processor determines a distance to a target “‘based on the pixel size of the target 118 ... relative to that of the frame’ and specifically the area (i.e., the size) of bounding box 16 around a target.” MTA Opp. 15 (citing Pet. 16–18, 28–29; Ex. 1039 ¶ 157). Petitioner contends that “Kumar determines the relative position of a target to the camera capturing the images based on the ‘known physical [bounding] box size of the object of interest’s type of object’ and the ‘physical length of the diagonal across the [bounding] box for an average instance of the object.’” *Id.* at 15–16 (citing Ex. 1007 ¶¶ 19–25, 37, Fig. 3A; Ex. 1008 ¶¶ 18–23, 32, claims 4, 5, 14, 15, 24, 25, Fig. 3A; Ex. 1003 ¶¶ 157–158). Petitioner also contends that “Khan teaches classification of a target into a type.” *Id.* at 15 (citing Ex. 1021 ¶¶ 3, 37–39, 44–63, Figs. 7, 8).

Petitioner contends that one of ordinary skill in the art would have combined the teachings of Beard, Laufer, Pierce, Khan, and Kumar, for the same reasons set forth in the Petition. MTA Opp. 11 (citing Pet. 10–13, 36–

41; Ex. 1039 ¶ 146). Petitioner additionally contends that one of ordinary skill in the art “would have been motivated to combine Beard, Laufer, Khan, and Kumar . . . with Pierce’s teachings of a drone having an on-board object tracking module that implements NNs for object detection and tracking” (*id.* at 11–12 (citing Ex. 1005 ¶¶ 27, 42, 44–46, Figs. 1, 6)). Petitioner asserts that adding Pierce to the combination “would have been applying a known technique . . . to improve similar devices (drones that identify, track objects) in the same way, with the predictable result of Beard’s UAV performing on-board object identification and tracking using NNs,” and that “there would have been a reasonable expectation of success.” *Id.* at 12 (citing Ex. 1005 ¶¶ 27, 42, 44–46, Figs. 1, 6).

We determine that Petitioner has made a sufficient showing that the proposed combination of Beard, Laufer, Pierce, Khan and Kumar would have taught or suggested the undisputed aspects of limitation [21.b], as well all aspects of limitation [21.c]—a limitation Patent Owner does not dispute. *See* MTA Reply 11–12. We now address the disputed issues, which relate to limitation [21.b] and Petitioner’s rationale to further combine the teachings of Beard and Laufer with those of Pierce, Khan and Kumar.

Patent Owner first disputes that Pierce teaches or suggests “applying at the reference aerial vehicle a machine learning model” as recited in limitation [21.b]. MTA Reply 9. According to Patent Owner, “Pierce never discloses any embodiments in which system 600 is both a drone and includes the module 615,” where “‘object tracking module 615’ may ‘process a neural network detection system.’” MTA Reply 9 (citing Ex. 1005 ¶¶ 38, 42, 45). Petitioner responds by pointing to “Pierce’s

teachings of a drone having an on-board object tracking module implementing NNs for object detection and tracking.” MTA Sur-reply 11.

We are not persuaded by Patent Owner’s argument, and we find that Pierce does, in fact, teach or suggest that object tracking module 615 may be onboard a drone. Pierce discloses that “drone system 600 may be drone 102,” and that “[d]rone system 600 may further include ... object tracking module 615,” which implements “various neural networks and/or computational systems.” Ex. 1005 ¶¶ 42, 45. Patent Owner acknowledges that a neural network may be a machine learning model. *See* MTA Reply 11 n.3. Thus, we see no basis for Patent Owner’s assertion that Pierce does not teach applying a machine learning model “at the reference aerial vehicle,” as recited in limitation [21.b].

Patent Owner next argues that Petitioner’s combination would use a machine learning model “to identify a bounding box outlining a portion of the image that includes detected features of the target,” as recited in limitation [21.b]. MTA Reply 11. According to Patent Owner, Petitioner’s “combinations do not teach/suggest [a machine learning (ML)] model ‘to identify a bounding box outlining . . . detected features.’” *Id.* In particular, Patent Owner asserts that “Beard is silent on ML model” and “Laufer/Pierce/Kumar are silent on detected features.” *Id.*

Patent Owner’s arguments are not persuasive because they do not address Petitioner’s combination as proposed. Petitioner relies on Pierce (not Beard) to supply the recited “machine learning model.” *See* MTA Opp. 13; *see also* Pet. 15 (citing Ex. 1003 ¶¶ 117–118) (relying on Laufer for teaching the machine learning feature)). Petitioner similarly relies on Kahn,

and not Laufer/Pierce/Kumar, to supply the recited bounding box outlining “detected features.” *See* MTA Opp. 12–13.

Patent Owner additionally argues that “Khan’s bounding in FIG. 7 is provided by a human document illustrator, and not an ML system,” and that “Khan uses the [Histogram of Oriented Gradients (HoG)] signal processing algorithm and not any ML system.” MTA Reply, 11; *see also* Ex. 1021, Fig. 3A (defining “HoG”). According to Patent Owner, “[a]n ML system is a customized trained system, and cannot be straightforwardly adapted to provide new functionality, e.g., supplying HoG features.” *Id.* at 11–12.

Patent Owner’s argument regarding an alleged “human document illustrator” that provides the “bounding in FIG. 7” of Khan is not persuasive because Patent Owner does not provide citations supporting this assertion. *See* MTA Reply 11. Nor can we find support in Kahn for Patent Owner’s assertion. Although Khan’s description of Figure 12 discloses that “regions (i.e., collections of pixels or vehicle landmarks) corresponding to semantic parts of each vehicle model . . . are *manually* labeled,” this disclosure relates to “a training phase” that appears to pertain to models that are later used to classify an actual detected vehicle. *See* Ex. 1021 ¶ 64 (emphasis added). Kahn also provides that “[a]ny suitable method may be used for detecting the presence, location, and pose of a vehicle in the captured image,” with a preferred method illustrated in Figures 12–14. *Id.* ¶ 44. In describing Figure 13, Kahn discloses that, during a “runtime phase,” the “[region of interest (ROI)] may be estimated as a foreground moving mask and a foreground-background mask may be computed either by background modeling for stationary cameras or by using optical flow and image-to-image alignment.” *Id.* ¶ 67. This disclosure plainly describes steps of a computer-implemented

process, not those of a human illustrator. In any case, as noted above, Petitioner relies on Kumar to supply the teaching of a bounding box output by a neural network. *See* MTA Opp. 13 (citing Ex. 1007 ¶¶ 2, 19; Ex. 1008 ¶ 1; Ex. 1039 ¶ 152). We are, thus, persuaded that Petitioner has made a sufficient showing of obviousness regarding the recitation of “applying . . . a machine learning model to the image, to identify a bounding box” in limitation [21.b].

Patent Owner’s argument that Khan’s HoG signal processing algorithm is not a machine learning system is also unavailing. Khan discloses that HoG is a feature extraction method of obtaining features that are then used for classification. *See* Ex. 1021 ¶¶ 49, 50. Specifically, these features are used to create a salient feature match distribution matrix (SMD) where, for example, in SMD 908, “each row 910 corresponds to the match scores from matching a particular vehicle model.” *Id.* ¶ 54. That is, “[e]ach row of the SMD 908 corresponds to a particular 3D vehicle model 602 and contains the HoG match scores (between the captured image 700 and a 3D vehicle model 602) computed at the 32 salient feature locations from the individual one of the 3D vehicle models 602.” *Id.* ¶ 55. Certain “p-scores” and “n-scores” are derived from the SMD, and “the detected vehicle 702 in the captured image 700 is classified using a two stage classifier method based on the derived p-scores and n-scores.” *Id.* ¶ 62. In particular, “a linear classifier, preferably a *support vector machine classifier (SVM)*, is *trained* on each window of the captured image 700 for making a decision as to whether there is a vehicle type match or not.” *Id.* (emphasis added). We agree with Petitioner’s declarant, Dr. Singhose, that these disclosures in

Khan of training a SVM classifier teach the use of a machine learning model to classify a target. *See* Ex. 1039 ¶ 151.

Patent Owner further argues that one of ordinary skill in the art would not have combined the cited references in the manner proposed by Petitioner. MTA Reply 9–10. Specifically, Patent Owner argues that “[a] POSITA would not implement an NN on Beard’s or Pierce’s processors,” because “Beard and Pierce do not disclose any processors suitable for NN execution.” *Id.* Patent Owner then makes a related argument that all of the combinations would render either Beard or Pierce inoperable for its intended purpose. *Id.* at 10. In particular, Patent Owner asserts that executing neural networks for image analysis on generic processors, rather than graphics processing units, “was known not to achieve real-time performance.” *Id.* (citing Ex. 2044, 6–7; Ex. 2045, 1–2; Ex. 2051, 1–2; Ex. 2052, 3). Patent Owner also argues that Petitioner’s proposed combinations are faulty because they “result in *duplicative computations* because Khan requires feature generation using a conventional HoG algorithm, but an NN from Laufer, Pierce, Kumar automatically extracts its own features that are not HoG features and are not usable by Khan, resulting in duplicative feature extraction.” *Id.* at 10–11 (emphasis in original).

Patent Owner’s motivation-to-combine arguments are not persuasive. Pierce teaches an object tracking module onboard an aerial vehicle, where the “object tracking module may be configured to process a neural network detection system.” Ex. 1005 ¶ 44. Thus, we disagree with Patent Owner’s argument that “Pierce do[es] not disclose any processors suitable for NN execution.” *See* MTA Reply 10. Petitioner’s combination proposes modifying Pierce’s tracking module, so that its specific native processing

capabilities are replaced with other processing capabilities provided by the other references. *See* MTA Opp. 11–12. Patent Owner does not adequately rebut Petitioner’s persuasive reasoning why one of ordinary skill in the art would have had reason to implement the known processing techniques of Kahn or Kumar onboard an aerial vehicle, particularly given Pierce’s specific disclosure of implementing “a neural network detection system” for object tracking onboard a drone. Ex. 1005 ¶ 44.

Petitioner’s argument concerning what it calls “duplicate computations” is not persuasive because we determine it would have been within the abilities of one skilled in the art to select and use the disclosed techniques in a compatible way. Petitioner’s combination primarily relies on Kahn to supply the “detecting” aspects of limitation [21.b] (e.g., MTA Opp. 12–13), and we do not see any basis to argue that Petitioner’s proposed combination would result in duplication of feature extraction techniques from other references. Regarding Patent Owner’s assertion that “an NN from Laufer, Pierce, Kumar automatically extracts its own features,” we note that Petitioner does not propose using the feature detection aspects of these other references. Petitioner’s combination relies on Kumar to supply the limitations relating to the use of machine learning to identify a bounding box, and Kahn to supply the limitations relating to detecting features within a bounding box. *See id.* 12–15. Patent Owner does not articulate a specific argument as to why Kumar’s bounding box and Kahn’s feature detection are incapable of being combined, as Petitioner proposes. We also note that proposed substitute claim 21 does not specify any particular “machine learning model,” or any particular method for detecting features within that model.

(3) *Conclusion regarding Obviousness*

Petitioner has persuasively explained how the combination of Beard, Laufer, Pierce, Khan, and Kumar teaches or suggests each limitation of proposed substitute claim 21, and has provided a persuasive explanation of how and why one of ordinary skill in the art would have combined those references with a reasonable expectation of success. *See* MTA Opp. 10–17; MTA Sur-reply 11–12; Pet. 10–27. Patent Owner’s responsive arguments are not persuasive. On the record before us, we determine Petitioner has shown by a preponderance of the evidence that proposed substitute claim 21 is unpatentable under 35 U.S.C. § 103 over the combined teachings of Beard, Laufer, Pierce, Khan, and Kumar.

e) *Obviousness of Dependent Proposed Substitute Claims 22–27, 31–33, and 35*

Petitioner contends that dependent proposed substitute claims 22, 23, 25–27, 31–33, and 35 would have been obvious for the reasons provided in the Petition with respect to corresponding original claims 2, 3, 8–10, 14–16, and 18, which, as we explained above, are canceled. MTA Opp. 17 (citing Pet. 27–43; Ex. 1039 ¶ 164). Although Petitioner omits proposed substitute claim 24 in referencing the contentions in the Petition (*see id.*), the statement of Ground 23 lists claim 24 (*see id.* at 10–11; *see also id.* at 24 (referencing “GND23 (SC 24)”), and the cited section of the Petition includes contentions for corresponding original claim 4, which corresponds to claim 24 (*see* Pet. 38). Accordingly, we consider proposed substitute claim 24 as subject to this ground.

Patent Owner does not dispute Petitioner’s contentions regarding proposed substitute claims 22–27, 31–33, and 35. *See generally* MTA Reply.

Petitioner has persuasively explained how the combination of Beard, Laufer, Pierce, Khan, and Kumar teach or suggest each limitation of proposed substitute claims 22–27, 31–33, and 35, and has provided a persuasive explanation of how and why one of ordinary skill in the art would have combined those references with a reasonable expectation of success. *See* Pet. 27–43; MTA Opp. 17. On the record before us, we determine Petitioner has shown by a preponderance of the evidence that proposed substitute claims 22–27, 31–33, and 35 are unpatentable under 35 U.S.C. § 103 over the combined teachings of Beard, Laufer, Pierce, Khan, and Kumar.

f) Conclusion

For the reasons set forth above, we conclude that Petitioner has proven by a preponderance of the evidence that proposed substitute claims 21–27, 31–33, and 35 would have been obvious and, therefore, unpatentable over the combined teachings of Beard, Laufer, Pierce, Khan, and Kumar. Accordingly, we deny Patent Owner’s Motion with respect to these proposed substitute claims.

4. Obviousness Grounds Challenging Proposed Substitute Claims 28, 30, and 34 (Grounds 24–26)

Petitioner’s remaining obviousness grounds (Grounds 24–26) add Malecki, Sahasrabudhe, and Hogasten, respectively, to the Beard-Laufer-Pierce-Khan-Kumar combination that we discuss at length above. Petitioner contends proposed substitute claims 28, 30, and 34 would have been obvious over these respective combinations for the reasons provided in the Petition with respect to corresponding original claims 11, 13, and 17, which, as we explained above, are canceled. MTA Opp. 17 (citing Pet. 43–50; Ex. 1039 ¶¶ 165–168). Patent Owner does not dispute Petitioner’s contentions

presented in the Petition as applied to proposed substitute claims 28, 30, and 34. *See generally* MTA Reply.

Petitioner has persuasively explained how the combinations of Beard, Laufer, Pierce, Khan, Kumar, Malecki, Sahasrabudhe, and Hogasten specified in Grounds 24–26 teach or suggest each limitation of proposed substitute claims 28, 30, and 34, and has provided a persuasive explanation of how and why one of ordinary skill in the art would have combined those teachings or suggestions with a reasonable expectation of success. *See* Pet. 43–50; MTA Opp. 17. On the record before us, we determine Petitioner has shown by a preponderance of the evidence that proposed substitute claims 28, 30, and 34 are unpatentable under 35 U.S.C. § 103 over the combined teachings of Beard, Laufer, Pierce, Khan, Kumar, Malecki, Sahasrabudhe, and Hogasten. Accordingly, we deny Patent Owner’s Motion with respect to these proposed substitute claims.

5. *Obviousness Based on Beard, Laufer, Pierce, and Ning
(Ground 27)*

In the Petition, Petitioner contends that Beard and Laufer teach or suggest each limitation of original claim 19, and that one of ordinary skill in the art would have had reason to combine those references with a reasonable expectation of success. *See* Pet. 10–27, 35. Patent Owner has not disputed those assertions. *See* PO Resp. 10–16 (presenting arguments exclusive to original claim 12); PO Sur-reply 1–24 (same).

Limitations [36.pre], [36.a], and [36.c] include no changes to the corresponding language of original claim 19, and limitations [36.b1] and [36.b2] are minimally amended to recite that the processor is configured to perform functions “at the reference aerial vehicle.” MTA, Claims App. Patent Owner does not dispute Petitioner’s contentions regarding these

limitations. *See* MTA Reply 9–12. Based on the complete record, and for the reasons explained in the Petition (*see* Pet. 10–27, 35) and the MTA Opposition (*see* MTA Opp. 18–19 (relying on Beard for the new language in limitations [36.b1] and [36.b2])), we determine Petitioner has persuasively shown that Beard and Laufer teach limitations [36.pre], [36.a], [36.b1], [36.b2], and [36.c], and has also persuasively demonstrated that one of ordinary skill in the art would have had reason to combine the teachings of those references with a reasonable expectation of success.

Limitation [36.d] recites new subject matter. We provide a brief overview of Ning, and then we address the parties’ arguments concerning the new subject matter of limitation [36.d] below.

a) Overview of Ning (Ex. 1034)

Ning relates to “vision-centric deep-learning-based road situation analysis,” including determining whether to present a warning signal to a vehicle driver based on the predicted future status of a detected object. Ex. 1034, code (57). Ning discloses “a deep neural network called Recurrent YOLO (You Only Look Once) or ROLO is provided as a core engine of the system.” *Id.* at 4:38–40. Ning’s ROLO “can connect the convolutional layers of YOLO to a recurrent neural network (RNN) long short-time memory (LSTM), for the purpose of real-time object detection and tracking.” *Id.* at 4:55–58.

b) Limitation [36.d]

Regarding limitation [36.d], Petitioner contends that “Ning discloses a YOLO [(You Only Look Once)] NN” that performs “object location estimates based only on a current full image.” MTA Opp. 19 (citing Ex. 1034, Abstract, 1:51–3:6, 4:38–54, 5:46–54, 6:15–43, 9:30–10:32, 10:55–11:13, 12:55–13:2, Figs. 2, 8; Ex. 1036, 779–780, Figs. 1, 2; Ex. 1039

¶¶ 175–176). Petitioner further contends that “Ning teaches the LSTM [(long short-term memory)] NN ‘refin[ing]’ its predicting and tracking of an object’s location, and repeating its object location predicting and tracking, ... thus teaching the object’s location is predicted *incrementally* as claimed.” *Id.* at 20 (emphasis in original) (citing Ex. 1034, 6:33–8:33, Figs. 1, 4; Ex. 1039 ¶ 177). Petitioner contends one of skill in the art would have combined the teachings of Ning with those of Beard and Laufer, and that in the proposed combination, Ning’s “YOLO NN has ‘high robustness,’ ‘high cost’” and the “LSTM NN has ‘medium robustness,’ ‘medium cost’ or ‘low robustness,’ ‘low cost.’” *Id.* at 21 (citing Ex. 1034, 4:55–5:3, 8:49–52, 10:50–54; Ex. 1039 ¶ 177–178).

Patent Owner argues in response that “the combinations do not teach [or] suggest two NNs having the cost relationship recited in claim element [36.d],” i.e., a system wherein the first neural network that is used to detect a target has robustness and compute costs greater than those of the second neural network that is used to determine the three-dimensional relative location of the target. *See* MTA Reply 12; MTA, Claims App. In particular, Patent Owner asserts that Ning’s LSTM (the second neural network) cannot process a frame until the YOLO (the first neural network) first processes the frame, and that because the “LSTM includes the cost incurred by the YOLO,” “[t]his makes the YOLO’s cost less than LSTM’s.” *Id.* Patent Owner also asserts that this relationship means “the YOLO and LST[M] may not even be considered two separate NNs.” *Id.* According to Patent Owner, Ning’s LSTM does not process images, but rather only receives input from the YOLO. *Id.*

Petitioner responds that Patent Owner “never shows how the YOLO has a lower cost,” and that “YOLO and LSTM are separate NNs in which the YOLO’s cost is higher, where the LSTM performs *incremental prediction* as claimed as it determines tracking parameters that predicts and tracks an object’s location in an image frame over time.” MTA Sur-reply 12 (emphasis in original) (citing Ex. 1034, 4:55–5:3, 5:46–54, 6:44–53, 8:41–54, Figs. 2, 3).

We agree with Petitioner. Ning discloses first determining whether a detected object is a candidate object with a YOLO, and, if so, using LSTM to track the object. *See* Ex. 1034, 4:46–49, 4:55–60. YOLO and LSTM are separate neural networks that may be connected to one another. *See id.* at 4:55–60. Ning also explains that YOLO is a “deep neural network” that “is used to recognize and detect a full image,” and that an LSTM “is one type of recurrent neural network (RNN) architecture.” Ex. 1034, 4:38–40, 4:48–60. As Petitioner asserts, the ’711 Patent itself points out that YOLO neural networks are high cost-high robustness. MTA Opp. 19 (citing Ex. 1034, 28:40–47). Accordingly, Patent Owner’s arguments regarding Ning are not persuasive.

c) Conclusion

Petitioner has persuasively explained how the combination of Beard, Laufer, Pierce, and Ning teaches or suggests each limitation of proposed substitute claim 36, and has provided a persuasive explanation of how and why one of ordinary skill in the art would have combined those references with a reasonable expectation of success. *See* Pet. 10–27, 35; MTA Opp. 16–21. On the record before us, we determine Petitioner has shown by a preponderance of the evidence that proposed substitute claim 36 is unpatentable under 35 U.S.C. § 103 over the combined teachings of Beard,

Laufer, Pierce, and Ning. Accordingly, we deny Patent Owner's Motion with respect to proposed substitute claim 36.

6. *Remaining Obviousness Grounds (Grounds 28–35)*

As discussed above, Petitioner has proven by a preponderance of the evidence that proposed substitute claims 21–28 and 30–36 are obvious and, therefore, unpatentable over the combinations of prior art references specified in Grounds 23–27, and we have already determined that Patent Owner's Motion should be denied as to these claims. Accordingly, we decline to address Grounds 28–35, which assert that the same claims are unpatentable over various alternative prior art combinations. *See* MTA Opp. 10–11, 21–25.

V. CONCLUSION⁴

We determine that Petitioner has not proven by a preponderance of the evidence that original claim 12 is unpatentable, and we thus confirm the patentability of original claim 12 and do not reach the Motion as to corresponding proposed substitute claim 29.

We grant Patent Owner's request to cancel original claims 5–7, and we deem original claims 1–4, 8–11, and 13–20 canceled as well, in view of the non-contingent aspect of the Motion.

⁴ Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. *See* 84 Fed. Reg. 16,654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. § 42.8(a)(3), (b)(2).

We grant Patent Owner's Motion as to amending original claim 20 because Petitioner has not proven by a preponderance of the evidence that corresponding proposed substitute claim 37 is unpatentable.

We deny Patent Owner's Motion as to amending original claims 1–4, 8–11, and 13–19 because Petitioner has proven by a preponderance of the evidence that corresponding proposed substitute claims 21–28 and 30–36 are unpatentable.

The result of this Decision is summarized by the following tables.

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1–3, 5, 6, 9, 10, 12, 14–16, 18–20	103 ⁵	Beard, Laufer		12
4	103 ⁶	Beard, Laufer, Khan		
7, 8	103 ⁶	Beard, Laufer, Kumar		
11	103 ⁶	Beard, Laufer, Malecki		
13	103 ⁶	Beard, Laufer, Sahasrabudhe		
17	103 ⁶	Beard, Laufer, Hogasten		

⁵ Because original claims 1–11 and 13–20 were cancelled, we do reach this ground of unpatentability as to those claims.

⁶ Because the original claims challenged in this ground were cancelled, we do not reach this ground.

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1, 3, 5–9, 15, 19, 20	102 ⁶	Pierce		
1, 3, 5–9, 15, 19, 20	103 ⁶	Pierce, Kumar		
2, 12, 18	103 ⁵	Pierce, Laufer		12
2, 12, 18	103 ⁵	Pierce, Kumar, Laufer		12
4	103 ⁶	Pierce, Khan		
4	103 ⁶	Pierce, Kumar, Khan		
17	103 ⁶	Pierce, Hogasten		
17	103 ⁶	Pierce, Kumar, Hogasten		
1, 3, 5–9, 14–16, 19, 20	103 ⁶	Pierce, Sahasrabudhe		
1, 3, 5–9, 14–16, 19, 20	103 ⁶	Pierce, Kumar, Sahasrabudhe		
2, 12, 18	103 ⁵	Pierce, Sahasrabudhe, Laufer		12
2, 12, 18	103 ⁵	Pierce, Kumar, Sahasrabudhe, Laufer		12
4	103 ⁶	Pierce, Sahasrabudhe, Khan		

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
4	103 ⁶	Pierce, Kumar, Sahasrabudhe, Khan		
17	103 ⁶	Pierce, Sahasrabudhe, Hogasten		
17	103 ⁶	Pierce, Kumar, Sahasrabudhe, Hogasten		
Overall Outcome				12

Motion to Amend Outcome	Claims
Original Claims Cancelled by Amendment	1–11, 13–20
Substitute Claims Proposed in Amendment	21–37
Substitute Claims: Motion to Amend Granted	37
Substitute Claims: Motion to Amend Denied	21–28, 30–36
Substitute Claims: Not Reached	29

VI. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that original claims 1–11 and 13–20 of the '711 Patent are canceled;

FURTHER ORDERED that original claim 12 is not unpatentable;

FURTHER ORDERED that Patent Owner's Motion is *granted* as to adding proposed substitute claim 37 to the '711 Patent;

FURTHER ORDERED that Patent Owner's Motion is *denied* as to adding proposed substitute claims 21–28 and 30–36 to the '711 Patent; and

FURTHER ORDERED that, because this is a Final Written Decision, parties to the proceeding seeking judicial review of the decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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