

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AXON ENTERPRISE, INC., DEDRONE HOLDINGS, INC., AND
SKYDIO, INC.
Petitioners

v.

AIRSPACE DEFENSE, INC.
Patent Owner

Case No. IPR2025-00629
Patent 10,514,711

**DECLARATION OF DR. WILLIAM SINGHOSE IN SUPPORT OF
PETITIONERS' REPLY AND PETITIONERS' OPPOSITION TO PATENT
OWNER'S CONTINGENT-IN-PART AND NON-CONTINGENT-IN-PART
MOTION TO AMEND**

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Second Declaration of Dr. William Singhose

I. INTRODUCTION

1. My name is Dr. William Singhose. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters contained herein.

2. I previously authored a declaration on February 23, 2025, which I understand was submitted as Exhibit 1003 to the Patent Trial and Appeal Board (“PTAB”) of the United States Patent and Trademark Office in case number IPR2025-00629. I may alternatively refer to the February 23, 2025, declaration as “Exhibit 1003” or “Original Declaration.”

3. In this Second Declaration, I incorporate the facts and opinions provided in my Original Declaration.

II. TASK SUMMARY AND MATERIALS REVIEWED

4. My Original Declaration addressed U.S. Patent No. 10,514,711 (EX1001, “’711 Patent”).

5. I have been informed that Airspace Defense, Inc. (“Patent Owner” or “PO”) submitted a Patent Owner’s Response (“POR”) in relation to claim 12 of the ’711 Patent, on December 20, 2025.

6. I have also been informed that Patent Owner filed a Contingent-in-Part and Non-Contingent-In-Part Motion to Amend for the ’711 Patent (Paper 21, “Motion to Amend” or “MTA”). I have been informed that the MTA is non-

contingent with respect original claims 1-4, 8-11, and 13-20, and contingent with respect to original claim 12, and replaces these claims with new claims 21-37 (“Substitute Claims” or “SCs”). The MTA requests cancelation of original claims 5-7 so I will not address them further.

7. Counsel for Petitioner has informed me that because the Motion to Amend was filed as “non-contingent” with respect to original claims 1-4, 8-11, and 13-20, the Board will issue a final decision on the patentability of Substitute Claims 21-28 and 30-37 rather than determining the patentability of the corresponding Original Claims. Counsel has also informed me that because the Motion to Amend was filed as “contingent” with respect to original claim 12, the Board will issue a final decision on the patentability of original claim 12, and if this claim is found unpatentable, issue a final decision on the patentability of Substitute Claim 29.

8. I have been asked to review the POR and MTA filed by Patent Owner regarding the ’711 Patent, the proposed Substitute Claims, and the exhibits cited by PO. I have been asked to provide an understanding of the technology relevant to the POR and MTA, to review certain prior-art references, and analyze whether or not those references disclose or teach limitations of the proposed Substitute Claims. Finally, I have been asked to assess the validity of the amended claims in view of Section 112 requirements such as written description, enablement, and definiteness.

The opinions stated in this declaration are from the perspective of a person of ordinary skill in the art (“POSITA”).

III. EXPERIENCE AND QUALIFICATIONS

9. My experience, qualifications, CV, and consulting fee are outlined in my Original Declaration. However, the MTA has introduced new claim limitations that relate to machine learning and image processing. I briefly review some of my relevant experience here.

10. One of the primary types of machine learning algorithms covered in the amended claims are neural networks. I started working with neural networks in the mid 1990's for the purpose of controlling flexible spacecraft. I created and trained neural networks to generate commands to move flexible systems, such as spacecraft, while minimizing residual vibration.

11. My initial work in this area utilized three types of neural networks to generate time-optimal and fuel-efficient commands. The first neural network was a two-layer network with nonlinear transfer functions in the hidden layer and linear functions in the output layer. The second neural network was a three-layer structure with two hidden layers with nonlinear transfer functions and a linear output layer. The final neural network was a radial basis function network. The results of my work in this area appeared in my Ph.D. thesis [1], as well as in a peer-reviewed publication [2].

12. I have worked in the area of image processing throughout my career. For example, in the early 2000's I developed methods to use optical-flow based tracking to extract data from video of human movement [3] [4]. Applications of this work was extended to tracking formation-flying satellite testbeds [5]. I have also used image processing extensively for tracking the position of cranes and crane payloads [6] [7] [8]. In fact, my developments in this area lead to the formation of a company - CAMotion Cranes - that successfully implemented image-tracking based control on hundreds of cranes.

IV. LIST OF EXHIBITS

13. In forming my opinions, I have reviewed the '711 Patent, its prosecution history and references cited by the Examiner, the materials cited in the List of Exhibits, and the materials cited throughout my Original Declaration, and this declaration.

Table 1: List of Exhibits

Ex. No.¹	Description
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¹ Citations to patents are made by column and line cite; citations to patent publications are made by paragraph number; citations to Exhibit 1002 are made with reference to the Bates-stamped pagination; citations to other exhibits are made to the

1001	U.S. Patent No. 10,514,711 to Bar-Nahum <i>et al.</i> , “Flight Control Using Computer Vision” (the “711 Patent”)
1002	File History for U.S. Patent No. 10,514,711
1003	Declaration of Dr. William Singhose
1004	Complaint for Patent Infringement, <i>Airspace Systems, Inc. v. Dedrone Holdings, Inc.</i> , Case No. 1-24-cv-01625 (E.D. VA), September 13, 2024
1005	U.S. Patent Application Publication No. 2017/0160751 to Pierce <i>et al.</i> , “System and Method for Controlling Drone Movement for Object Tracking Using Estimated Relative Distances and Drone Sensor Inputs” (“Pierce”) filed December 5, 2016, published June 8, 2017
1006	U.S. Provisional Application No. 62/263,510 to Pierce <i>et al.</i> , “System and Method for Controlling Drone Movement for Object Tracking Using Estimated Relative Distances and Drone Sensor Inputs” (“Pierce Provisional”), filed December 4, 2015
1007	U.S. Patent Application Publication No. 2017/0161911 to Kumar <i>et al.</i> , “System and Method for Improved Distance Estimation of Detected Objects” (“Kumar”) filed December 5, 2016, published June 8, 2017
1008	U.S. Provisional Application No. 62/263,496 to Kumar <i>et al.</i> , “System and Method for Improved Distance Estimation of Detected Objects” (“Kumar Provisional”), filed December 4, 2015
1009	U.S. Patent No. 9,769,387 to Beard <i>et al.</i> , “Action Camera System for Unmanned Aerial Vehicle” (“Beard”) filed November 5, 2014, published September 19, 2017

page number of the document itself. Cites to EX1035 and 1036 are made to the underlying publication/paper itself.

1010	U.S. Patent Application Publication No. 2017/0059692 to Laufer <i>et al.</i> , “Mitigation of Small Unmanned Aircraft Systems Threats” (“Laufer”) filed August 26, 2016, published March 2, 2017
1011	U.S. Patent No. 8,874,283 to Cavote, “Drone for Inspection of Closed Space and Method Thereof” (“Cavote”) filed December 4, 2012, published October 28, 2014
1012	Internet Archive Wayback Machine screenshot of www.lauferradarsystems.com/technology , dated August 1, 2017
1013	Laufer Wind, Eagle Take Minimization System, Contract DE-EE0007884.0000, Final Technical Report, dated March 28, 2018
1014	U.S. Patent Application Publication No. 2003/0143524 to Lerner, “Method and System for Determining the Amount, Distribution and Confirmation of Genetic Material in a Cell” (“Lerner”) filed January 31, 2002, published July 31, 2003
1015	U.S. Provisional Application No. 62/405,972 to Bar-Nahum <i>et al.</i> , “Multimodal Sensor Empowered Awareness Engine for Target Recovery and Object Path Prediction” (“’972 Provisional”), filed October 9, 2016
1016	Quadrotor Helicopter Flight Dynamics and Control: Theory and Experiment, Hoffmann <i>et al.</i> , American Institute of Aeronautics and Astronautics
1017	DJI Spreading Wings S1000+ User Manual, Version 1.4, dated January 2016
1018	Excerpts from <i>Control Theory for Humans</i> , Jagacinski and Flach, 2003
1019	Excerpts from <i>Control Systems Engineering</i> , Nise, 2004
1020	Excerpts from <i>Modern Control Systems</i> , Dorf and Bishop, 2005
1021	U.S. Patent Application Publication No. 2012/0106800 to Khan <i>at al.</i> , 3-D Model Based Method for Detecting and Classifying Vehicles in Aerial Imagery (“Khan”), filed October 28, 2010, published May 3, 2012
1022	PCT International Publication Number WO2017/123477 to Hogasten, Vehicle Based Radar Upsampling (“Hogasten”), filed January 6, 2017, published July 20, 2017, designating the U.S. and filed in English

1023	U.S. Provisional Application No. 62/277186 to Hogasten, “Vehicle Based Radar Upsampling” (“Hogasten Provisional”), filed January 11, 2016
1024	U.S. Patent Application Publication 2013/0301905 to Malecki et al., “System and Method for Determining an Orientation and Position of an Object” (“Malecki”), filed April 10, 2013, published November 14, 2013
1025	U.S. Patent Application Publication 2012/0004844 to Sahasrabudhe et al., “Formation Flying Method and System” (“Sahasrabudhe”), filed June 29, 2011, published January 5, 2012
1026	Claim Listing of Challenged Claims
1027	Siemens SIMATIC VS72X Manual, 2005
1028	<i>Command Limiting in Reconfigurable Flight Control</i> , Bodson et al., Journal of Guidance, Control, and Dynamics, Vol. 21, No. 4, July-August 1998
1029	Stipulation Email on May 29, 2025
1031	Definition of “autonomous” dated September 16, 2016
1032	Definition of “autopilot” dated September 22, 2015
1033	Transcript of Deposition of Dr. Nikolaos Papanikolopoulos in IPR2025-00629
1034	U.S. Patent No. 9,760,806 to Ning et al., “Method and System for Vision-Centric Deep-Learning-Based Road Situation Analysis” (“Ning”) filed May 11, 2016, published September 12, 2017
1035	Big/Little Deep Neural Network for Ultra Low Power Inference, Park et al., <i>2015 International Conference on Hardware/Software Codesign and System Synthesis Proceedings</i> , January 20, 2016 (“Park”)
1036	You Only Look Once: Unified, Real-Time Object Detection, Redmon et al., <i>2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR) Proceedings</i> , February 6, 2017 (“Redmon”)
1037	Declaration of Professor Hall-Ellis

V. TECHNICAL BACKGROUND

14. See Section IX of my Original Declaration (EX1003) for a technology background pertinent to the '711 Patent.

VI. OVERVIEW OF THE CHALLENGED PATENT

15. See Section VI of my Original Declaration (EX1003) for an overview of the '711 Patent.

VII. LEGAL STANDARDS

16. The Legal Standards provided to me were described in my Original Declaration.² In addition to those legal standards, I have been informed by counsel as to the legal requirements under Section 112 of the patent code. I briefly review my understanding of those requirements here.

A. INDEFINITENESS

17. I have been informed that, in order to be valid, the claims of a patent must be sufficiently definite that one skilled in the art can determine the metes and bounds of the claimed invention. I have been informed that a patent claim is deemed “indefinite” if the claim, read in light of the patent’s specification and prosecution history, fails to inform, with reasonable certainty, those skilled in the art about the

² EX1003 (Original Declaration), § V.

scope of the invention. I understand that a claim must be precise enough to afford clear notice of what is claimed, thereby apprising the public of what is still open to them.

B. WRITTEN DESCRIPTION

18. I have been informed that, in order for claims to be valid, the claims of a patent must provide written description support for each limitation of the claims. I have been informed that a patent claim lacks written description if the specification fails to convey with reasonable clarity to a POSITA that the inventor was in possession of the invention as of the filing date sought. I have been informed that this requirement relies on an objective inquiry into what is contained within the specification, and that while the precise terms appearing in the claims need not necessarily appear in the specification, there must be sufficient detail in the specification that a POSITA can clearly conclude that the invention described in the claims had been invented as of the filing date sought.

19. I have been informed that to satisfy the written description requirement, the specification must actually or inherently disclose each element of the claims.

20. I have been informed that for the disclosure to be inherent, the missing descriptive matter must necessarily be present in or unavoidably be taught by the specification, such that a POSITA would recognize such disclosure.

21. I have been informed that subject matter that is not disclosed, but would be obvious over what is expressly disclosed, does not satisfy the written description requirement.

22. I have been further informed that a claim is not patentable if the claimed invention was otherwise available to the public before the effective filing date of the claimed invention.

C. ENABLEMENT

23. I have been informed that, in order for claims to be valid, the specification must enable the full scope of the invention as defined by its claims. The specification must teach POSITAs how to make and use the full scope of the invention without undue experimentation.

VIII. CLAIM CONSTRUCTION—ORIGINAL CLAIM 12

24. Claim 12 recites the following:

“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.”

25. I understand that Patent Owner seeks a “plain and ordinary meaning” construction of “autonomously navigating the reference aerial vehicle towards the received geographical location” as “making navigation decisions by the reference

aerial vehicle by-itself, without outside control.” [POR at 10-12.] In my opinion, this construction is wrong. It is an overly restrictive interpretation that demands all navigation decisions be made on the aerial vehicle and demands the complete absence of outside control. This narrow interpretation is not the plain and ordinary meaning of “autonomously navigating...” and is contradicted by the specification. In my opinion, Patent Owner’s construction should be rejected.

A. PATENT OWNER’S (PO’S) INCONSISTENT CONSTRUCTIONS

26. I understand that Patent Owner has presented several changing interpretations of the phrase “autonomously navigating” throughout this proceeding. In the POPR, Patent Owner proposed two different and inconsistent plain and ordinary meanings. Patent Owner first argued that one plain and ordinary meaning was “performing navigation by the reference UAV itself.” [POPR at 30.] I do not agree with this construction. I also note that the claim does not recite or require a “UAV” and instead recites a “reference aerial vehicle.” I note that the specification says the “interceptor aerial vehicle” can include an “airplane,” a “helicopter,” or “any other vehicle capable of flight,” [’711 Patent, 3:47-51.] In my opinion, a suggestion that claim 12 is limited to unmanned aerial vehicles (UAVs) is inconsistent with the claim and specification.

27. In the POPR, Patent Owner also argued that the phrase “means making flight decisions by a component of the reference UAV itself.” [POPR at 31.] Again,

I also disagree with this construction for at least the reason that it limits the claim language to require a UAV.

28. In their latest arguments, Patent Owner advocates for yet another interpretation, even narrower, that the plain and ordinary meaning is “making navigation decisions by the reference aerial vehicle by-itself, without outside control.” [POR at 11-12.] I understand that Patent Owner’s expert, Dr. Papanikolopoulos, concedes that Patent Owner’s current proposal is not the same as the prior proposals. [EX2025 at 87 (FN2).] In my opinion, Patent Owner’s inconsistent and changing position on the plain and ordinary meaning of “autonomously navigating...” justifies rejecting Patent Owner’s new, overly-narrow interpretation.

B. THE BOARD ALREADY REJECTED PATENT OWNER’S ATTEMPT TO LIMIT THE PERFORMANCE OF METHOD STEPS TO ONBOARD THE AERIAL VEHICLE

29. Patent Owner’s attempt to limit the “autonomously navigating” step to performance “by the reference vehicle by-itself, without outside control” recycles logic the Board already rejected. In the POPR, the Patent Owner argued that the step of “detecting a target in the image including by applying a machine learning model to the image” in claims 1 and 20 should be interpreted narrowly to require performance of that step “aboard the reference UAV.” [POPR at 12-17.] The Board rejected that interpretation and I agree. [ID at 8.] The Board reasoned that the step

“merely require[s] that a target be ‘detected,’” and that the step “do[es] not require that target detection be performed ‘aboard the reference UAV.’” [*Id.*] The Board explained that the “Specification makes clear that the claims should not be limited to aspects of the disclosed embodiments, as Patent Owner proposes to do here.” [*Id.* (citing Ex. 1001, 2:56-59 (“The invention is described in connection with such embodiments, but the invention is not limited to any embodiment. The scope of the invention is limited only the claims...”)].] The Board further reasoned that Patent Owner “fails to cite any lexicographic definition or clear and unambiguous disclaimer of claim scope sufficient to limit the claims in the manner it proposes.” [*Id.* at 9.]

30. In my opinion, Patent Owner’s interpretation of “autonomously navigating” takes the same approach it took with the “detecting” limitations. Under Patent Owner’s proposed construction, not only must the step be performed onboard the reference aerial vehicle, but it must be performed “by the reference aerial vehicle *by-itself, without outside control.*” The Board’s logic in rejecting the requirement of onboard performance of the “detecting” limitations applies equally to Patent Owner’s even narrower interpretation of “autonomously navigating,” as I have seen nothing in the claims, specification, or extrinsic evidence that warrants that interpretation.

C. INTRINSIC EVIDENCE DOES NOT SUPPORT PATENT OWNER’S INTERPRETATION

31. Regarding the claims, no claim elements require the aerial vehicle to perform the step of “autonomously navigating” by-itself, without any outside control. The step itself does not recite where the step is performed and does not exclude performance or involvement by another component. The context of the claim also does not limit performance to the aerial vehicle. Claim 12 depends from claim 1, and is a “method of performing a flight control operation of a reference aerial vehicle” that does not recite where that method is performed, let alone that it is performed entirely on the aerial vehicle alone without outside influences or guidance. [’711 Patent, claims 1, 12.] I reiterate that this narrow, localized requirement is what the Board recognized in rejecting Patent Owner’s construction of the “Detecting Limitations” in the ID. [*Supra* Section VIII.B.].

32. The specification also does not support Patent Owner’s interpretation. Patent Owner’s improper attempt to limit the term to aspects of disclosed embodiments alone warrants rejecting Patent Owner’s interpretation. Each of Patent Owner’s citations uses permissive language and is described as an example embodiment. For example, Patent Owner cites to 9:38-43 of the ’711 Patent, which states that the CPU “may” be configured to perform flight decisions in one “example” of a UAV “embodiment[.]” [*See also* ’711 Patent, 9:7-10 (stating that the Fig. 3A discussion is “in accordance with some embodiments”); *see also id.*, 9:49-51 (describing “other embodiments”); 15:28-31 (stating that the process of Figure 4

is performed by the UAV “[i]n some embodiments”).] The Board acknowledged in the institution decision that importing these type of example embodiments is improper, because the ’711 Patent “makes clear that the claims should not be limited to aspects of the disclosed embodiments.” [ID at 8-9 (citing ’711 Patent at 2:56-59).] I also note that none of Patent Owner’s citations include a lexicographic definition of “autonomously navigating” or a clear and unambiguous disclaimer that would justify limiting the term to performance solely on the aerial vehicle without any outside control.

33. The Patent Owner's citations also do not even support its interpretation. For example, Patent Owner cites to the ’711 Patent at 9:25-27 for support. However, this passage simply states that a CPU controls "overall operation" of a UAV. It does not specifically require the UAV makes “navigation decisions” without “outside control” and certainly does not preclude outside control. In fact, a few sentences later, the ’711 Patent states the CPU “*may* be configured to **perform** one or more flight decisions for the UAV,” with an example being “provid[ing] one or more flight commands to a flight controller module.” [’711 Patent, 9:38-43.] Based on that example, Patent Owner states that the CPU ““performs one or more flight decisions for the UAV’ **by providing** ‘one or more flight commands.’” [POR at 11.] However, the CPU **providing commands** does not require the aerial vehicles’ CPU to actually **make** flight decisions (let alone “navigation decisions”) **by itself**. Nor does the

description preclude the UAV from receiving **any** outside control (e.g., a ground station providing commands or guidance to the UAV or modifying the UAV's commands in-flight, such as a speed or location). [’711 Patent, 9:38-43.].

34. The other sections cited by the Patent Owner also are not supportive of their narrow construction. For example, Patent Owner cites to the ’711 Patent at 9:49-51. However, this teaching broadly says that the “[i]n other embodiments, the CPU is configured to autonomously fly UAV 301” and does not discuss how the UAV flies autonomously. Furthermore, it does not describe the UAV making any “navigation decisions,” what “navigation decisions” are, or that such decisions are made by the reference vehicle itself “without outside control.” Finally, the citation that the Patent Owner makes to the ’711 Patent at 16:49-55 is unrelated to claim 12 because it concerns the autonomous adjustment of flight direction and speed based on “location and size of the target within the captured image.” This control action occurs **after** an aerial vehicle has navigated to a received location and is capturing images of the target. [’711 Patent at 15:64-16:55, Fig. 4 (steps 404, 406, 408).] “[A]utonomously navigating the reference aerial vehicle towards the received geographical location” of claim 12 concerns how the reference aerial vehicle gets to that received location in the first place. [*Id.*]. Finally, the last portion of this long citation, 16:49-55, does not limit performance of that action to on-board the aerial vehicle itself or preclude all outside control.

35. Patent Owner's interpretation of "autonomously navigating" also improperly excludes disclosed embodiments. Claim 12 recites, in part, “**receiving a geographical location** associated with the target detected at least in part **using a ground-based sensor**” and “autonomously navigating the reference aerial vehicle **towards the received geographical location.**” [’711 Patent, Claim 12.] The specification describes that ground station 104 “is used to manage interceptor aerial vehicle 102,” including by providing “instructions, commands, sensor data, and/or other data that can be used by interceptor aerial vehicle 102 to . . . navigate to and/or capture a target aerial vehicle.” [’711 Patent, 3:43-61.] The specification discloses that the reference aerial vehicle receives “updated” location data from ground-based sensors and that the location is “continually received as a new or updated location of the target,” including as a “stream of locations tracked for the target.” [’711 Patent at 4:14-22, 15:50-63.] The “received location is utilized to navigate towards the received location.” [*Id.*, 15:64-16:3; *see also id.* at 4:34-37 (explaining the ground station communicates in real time with the aerial vehicle and can “redirect” the aerial vehicle).] Therefore, contrary to Patent Owner’s interpretation, the claim language “autonomously navigating the reference aerial vehicle **towards the received geographical location**” is taught in the ’711 Patent as occurring **with** outside control. This outside control is achieved with continually updated locations and navigation commands being received from a ground-based sensor. [*Id.*; *see also id.* at 29:39-41]

and 29:47-49 (describing techniques be “distributed throughout one or more devices”).]

36. Given the above teachings from the '711 Patent, it is clear that Patent Owner’s requirement that “autonomously navigating the reference aerial vehicle” means “making *navigation decisions* by the reference aerial vehicle by-itself, *without outside control*,” conflicts with, and even excludes, portions of the specification. [*Id.*] I note that Patent Owner also does not cite to any prosecution history defining “autonomously navigating” or otherwise disclaiming or disavowing subject matter in a way that would support their narrow interpretation. [POR, 10-12.]

D. PATENT OWNER’S EXTRINSIC DICTIONARY DEFINITIONS ARE TEMPORALLY IRRELEVANT AND ITS ARGUMENTS ARE UNSUPPORTED

37. I understand that the ordinary and customary meaning of a claim term is the meaning at the time of invention, i.e., as of the filing date of the underlying patent application. The Patent Owner ignores this rule by putting forth dictionary definitions of “autonomous” that are not from the proper time period. [POR at 11.] Patent Owner's dictionary definitions appear to be dated “7/14/25, 12:27 PM” and “7/14/25, 12:29 PM.” [EX2011 (dated in upper left corner); EX2012 (dated in upper left corner).] This indicates that they are dictionary definitions as of July 2025, which is almost 9 years after the '711 Patent’s earliest priority date. [*Id.*] These definitions thus have not been shown to reflect the meaning of “autonomous” to a POSITA at

the correct time. I also note that Patent Owner cites to its expert declaration only a single time at the end of their claims construction section. Therefore, almost all of the statements are unsupported attorney argument. Regardless, the expert declaration does nothing to support Patent Owner's narrow interpretation of "autonomously navigate". [*Compare* EX2025, ¶¶84-87, with POR at 10-12.]

E. THE CORRECT INTERPRETATION OF CLAIM 12

38. In my opinion, to the extent any construction is necessary, the plain and ordinary meaning of “autonomously navigating the reference aerial vehicle towards the received geographical location” is “navigating the reference aerial vehicle towards the received geographical location without human control.” This meaning is fully supported by the intrinsic record and extrinsic sources.

39. The '711 Patent explains that its purported invention addresses issues in the background art associated with “flight controllers manually operated by a human user.” [’711 Patent at 1:27-34.] For example, human control may require a “human user to have visual sight of the aerial vehicle and/or an image captured by the aerial vehicle,” and challenges can exist when “a trained human user is unavailable or unable to react quickly enough to perform a desired flight maneuver.” [*Id.*] The patent states that “it may not be desirable to manually control the interceptor aerial vehicle to follow the target UAV.” [*Id.* at 3:24-26.] As such, the ’711 Patent’s use of “autonomous” is associated with eliminating direct manual

control, rather than entirely on-board control. This analysis supports the interpretation that “autonomously navigating the reference aerial vehicle towards the received geographical location” is “navigating the reference aerial vehicle towards the received geographical location without human control.”

40. The Petitioner's interpretation of “autonomously navigating” is also consistent with, and inclusive of, the '711 Patent's embodiments describing that ground stations provide commands to the reference aerial vehicle, including commands to navigate the aerial vehicle towards the target location. ['711 Patent at 3:54-61, 4:34-37, 12:15-17, 14:10-13, 15:59-63.]

41. Extrinsic evidence also supports Petitioner's interpretation of “autonomous.” In contrast to Patent Owner's Cambridge English Dictionary definition from 2025, Petitioner's dictionary definition of “autonomous” is from September 16, 2016. [EX1031.] The definition provided in EX1031 defines “autonomous” in a vehicle context as “navigated and maneuvered by a computer, **without a need for human control or intervention** under normal road conditions.” [EX1031, 5.] In my opinion, this supports Petitioner's interpretation of “autonomously navigating.”

42. I also note that Patent Owner's Cambridge English Dictionary citation even supports Petitioner's interpretation when it states “an autonomous machine or

system is able to operate **without being controlled directly by humans,**” with an “autonomous vehicle” being a relevant example. [EX2012.]

43. The definitions of EX1031 and EX2012 thus both support how “autonomously navigating the reference aerial vehicle towards the received geographical location” is navigating the reference aerial vehicle towards the received geographical location without human control.

44. Finally, I also note that Patent Owner’s own expert provided testimony that support’s Petitioner’s interpretation. When testifying about different levels of “autonomy” in the context of autonomous vehicles, Patent Owner’s own expert distinguished them based on level of human involvement: “As you increase the autonomy, you take the human more and more out.” [EX1038, 21:14-24:11 (also confirming that in 2015 people believed that complete autonomy meant there is no human involved).]

45. The correct meaning of “autonomously navigating” in the context of the ’711 Patent excludes human control, not all outside input. Given the patent’s discussion of the challenges with direct manual control of aerial vehicle flight, the use of outside inputs from computers on the ground when navigating, would fall within the meaning of the word “autonomous” at the time.

IX. CLAIM 12 IS UNPATENTABLE

A. GROUNDS 1, 9, 10, 17, AND 18 RENDER CLAIM 12 OBVIOUS UNDER BOTH PETITIONER’S CORRECT INTERPRETATION OF CLAIM 12 AND PATENT OWNER’S ERRONEOUS INTERPRETATION OF CLAIM 12

46. In my opinion, the Petition’s grounds of Beard and Laufer (Ground 1), Pierce and Laufer (Ground 9), Pierce, Kumar, and Laufer (Ground 10), Pierce, Sahasrabudhe, and Laufer (Ground 17), and Pierce, Kumar, Sahasrabudhe, and Laufer (Ground 18) each renders claim 12 obvious. [Pet. at 34, 71, 80.] I understand that all of Patent Owner’s patentability arguments depend on its erroneous interpretation of “autonomously navigating the reference aerial vehicle.” That is, Patent Owner makes their arguments assuming the phrase means “making navigation decisions by the reference aerial vehicle by-itself, without outside control.” [POR at 10-18.] If that interpretation is rejected, then it is my understanding that all of Patent Owner’s patentability arguments must also be rejected. However, even under Patent Owner’s erroneous interpretation, these grounds still render obvious claim 12. The following sections will demonstrate obviousness of Claim 12, even when using the erroneous claim construction put forth by the Patent Owner.

1. Ground 1: Beard and Laufer

47. The Petition demonstrated that the Beard-Laufer combination teaches UAV 100 is brought to within an imaging range of the target using an interception location and autopilot commands (*autonomously navigating the reference aerial vehicle towards the received geographical location*). [Pet. at 10-13, 34; EX1010,

¶¶0022-0031, 0038-0040, Fig. 4.] Because UAV 100 utilizes the autopilot commands to control its flight, UAV 100 is navigating itself towards the interception location autonomously, without any human control. [Pet. at 10-13, 34; EX1010, ¶¶0022-0031, 0038-0040, Fig. 4.] I note that the definition of “autopilot” means that “piloting” occurs “without human involvement.” [EX1032, 5.] Laufer teaches that the autopilot commands “pilot an interceptor aircraft to [the] interception location” and that they include “a yaw command, pitch command, and/or motor speed commands.” [EX1010, ¶¶0040-0041 (further noting “[a]ircraft control commands [] are used by interceptor aircraft flight controller [] to pilot the interceptor aircraft toward interception location”).] Laufer further explains that the autopilot commands are generated by an “autopilot command module” based on the interception location and an “interceptor aircraft dynamics model.” [*Id.*, ¶0040.] Laufer also distinguishes its autopilot commands from human control, explaining that in some embodiments “a user can manually override control of [the] interceptor aircraft” via a “manual input.” [*Id.* at ¶¶0026, 0031, 0037.] Even the Patent Owner acknowledges how Laufer’s autopilot commands are separate from human control, stating “Laufer’s autopilot commands may not be provided by a human, and may instead be generated by a computer, such as one of Laufer’s autopilot command module[sic].” [POR at 14.] As such, the combination of Beard and Laufer meets the correct interpretation

of navigating the reference aerial vehicle towards the received geographical location without human control. [*Id.*; see Section VIII.E.]

48. As I noted above, Patent Owner’s arguments against Beard and Laufer depend on its erroneous interpretation that the “‘plain and ordinary / customary’ meaning of ‘autonomously navigating the reference aerial vehicle’” is “making navigation decisions by the reference aerial vehicle by-itself, without outside control.” [POR at 10-12.] Because all of Patent Owner’s arguments hinge on that incorrect interpretation, they should be rejected.

49. However, Patent Owner’s non-obviousness arguments also fail under Patent Owner’s incorrect interpretation. As an initial matter, I note that Patent Owner never challenges the combination of Beard and Laufer, instead focusing on Laufer individually, which does not address the combined teachings. Additionally, I note that Patent Owner’s statements amount to unsupported attorney argument because it only cites to its expert declaration (EX2025) to support the generic allegation that “claim 12 is patentable” (POR at 18). There is no cited expert support for any of its specific arguments, including its arguments regarding a POSITA’s motivation to combine prior art and expectation of success. [POR at 12-18.]

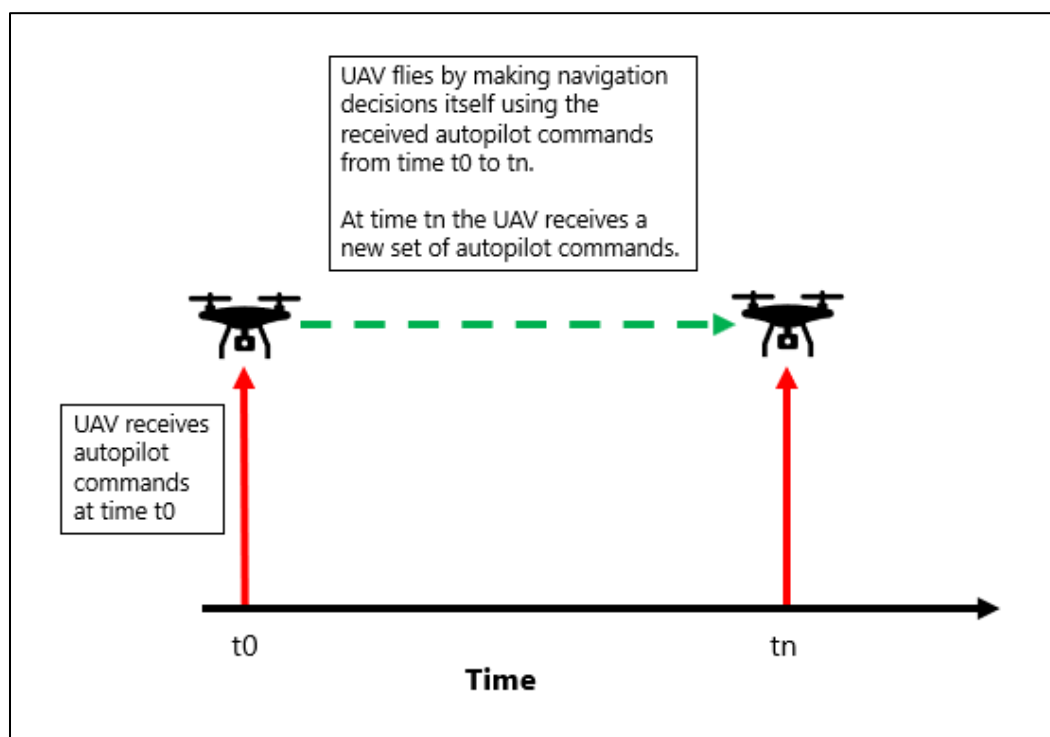
50. I understand that Patent Owner’s attorney argument against Beard and Laufer is that a POSITA would not have “combined Beard and Laufer, at least because the proposed combination does not provide a reasonable expectation of

achieving autonomous navigation of an aerial vehicle, and thus the claimed invention of claim 12.” [POR at 12-13.] The Patent Owner focusses on how Laufer purportedly describes that its central controller 115 is “not on-board a UAV” and autopilot commands not generated by the UAV, and that Laufer’s UAV thus “does not navigate itself.” [*Id.* at 13-15.] Patent Owner further relies on the same arguments to conclude that “Laufer does not teach or suggest ‘autonomously navigating the reference aerial vehicle’” and “the Beard-Laufer combination does not teach all of the limitation[sic] of claim 12.” [*Id.* at 15-16.] I do not agree. As an initial matter, as I note above, Patent Owner’s arguments are unsupported by an expert or POSITA justification.

51. Moreover, as discussed above (Section VIII.C), claim 12 does not require that “autonomously navigating the reference aerial vehicle towards the received geographical location” occurs on-board a UAV, and Patent Owner’s interpretation conflicts with claim 12 itself and the specification, which makes Patent Owner’s entire argument baseless. Moreover, regardless of whether or not autopilot commands are determined on board UAV 100 in the Beard-Laufer combination, the combination teaches that UAV 100 uses the autopilot commands to control itself toward the received interception location. [Pet. at 10-13, 34; EX1010, ¶¶0022-0031, 0038-0040, Fig. 4.] A POSITA would have understood that during the time period in which UAV 100 uses such autopilot commands, it is making navigation decisions

by itself, without any outside control. [*Id.*] This is because the use of autopilot commands by UAV 100 means that UAV 100 is autonomously controlling itself—for example, controlling its yaw, pitch, and/or motor speed—according to the autopilot commands and without any other external or outside control. [Pet. at 10-13, 34; EX1010, ¶¶0022-0031, 0038-0040, Fig. 4.]

52. I provide an example of this concept in the timeline illustration below. At time t_0 , the UAV receives autopilot commands. It then flies autonomously without outside control until a later time, t_n . At time t_n the UAV receives updated autopilot commands. During the time period from t_0 to t_n , the UAV is autonomously navigating, even under Patent Owner's erroneous construction.



Timeline Illustration

53. Patent Owner’s own expert confirmed that a UAV controlling itself in this manner is an example of “making navigation decisions” under Patent Owner’s faulty construction:

Q. Is changing speed in response to a speed command a navigation decision?

A. Yes.

[EX1033, 124:7-9; *see also id.*, 127:2-5 (similar testimony regarding pitch).]

54. This is exactly what UAV 100 itself would be doing even if the autopilot commands for speed were coming from the ground—the UAV would be changing speed in response to a speed command. Patent Owner’s expert thus confirmed this (in and of itself) is a navigation decision which would satisfy Patent Owner’s interpretation. Thus, Beard and Laufer teach “making navigation decisions by the reference aerial vehicle by-itself, without outside control,” teaching Patent Owner’s erroneous interpretation. *Id.*

55. Regarding the other elements of claim 12, Patent Owner does not contest that Beard and Laufer teach them. [Pet. at 10-13, 18-27, 34; POR at 12-16.]

2. Grounds 9 and 10: Pierce and Laufer (Ground 9)/Pierce, Kumar, and Laufer (Ground 10)

56. The Petition demonstrated that in the Pierce-Laufer/Pierce-Kumar-Laufer combinations, drone 102 is brought to within an imaging range of the target using an interception location and autopilot commands (*autonomously navigating*

the reference aerial vehicle towards the received geographical location). [Pet. at 68-71; EX1010, ¶¶0022-0031, 0038-0040, Fig. 4.] Laufer’s teachings are utilized in these grounds in the same way as in the Beard-Laufer ground. [See Pet. at 10-13, 34, 68-71.] As such, for the same reasons discussed above, the Pierce-Laufer/Pierce-Kumar-Laufer combinations teach the use of autopilot commands by drone 102 that meet both Petitioner’s correct interpretation and Patent Owner’s erroneous interpretation of “autonomously navigating the reference aerial vehicle towards the received geographical location.” [See Section IX.A.1.] I note that Patent Owner does not contest that the Pierce-Laufer/Pierce-Kumar-Laufer combinations teach the other elements of claim 12. [Pet. at 56-60, 68-71; POR at 16-17.]

3. Grounds 17 and 18: Pierce, Sahasrabudhe, and Laufer (Ground 17)/ Pierce, Kumar, Sahasrabudhe, and Laufer (Ground 18)

57. Pierce, Sahasrabudhe, and Laufer (Ground 17) and Pierce, Kumar, Sahasrabudhe, and Laufer (Ground 18) render obvious Claim 12 for the same reasons discussed in the Petition and in Section IX.A.2, *supra*. [Pet. at 80.]

X. CONCLUSION REGARDING CLAIM 12

58. In view of the above, it is my opinion that claim 12 is unpatentable.

XI. OVERVIEW OF THE SUBSTITUTE CLAIMS

A. TABLE CORRELATING ORIGINAL CLAIM TO SUBSTITUTE CLAIM

59. I understand that in Patent Owner’s Motion to Amend, Patent Owner has sought to amend the independent claims by proposing new substitute claims.

The table below compares the Original Claims to the Substitute Claims, with independent claims emphasized in bold italics.

Original Claim	Dependency	Substitute Claim	Dependency
<i>1</i>	None	<i>21</i>	None
2	1	22	21
3	1	23	21
4	1	24	21
5	1	Canceled	None
6	5	Canceled	None
7	1	Canceled	None
8	7	25	21
9	1	26	21
10	1	27	21
11	1	28	21
12	1	29	21
13	1	30	21
14	1	31	21
15	1	32	21
16	15	33	21

17	1	34	21
18	1	35	21
19	None	36	None
20	None	37	None

B. LIST OF SUBSTITUTE CLAIMS

60. Patent Owner also provided annotations showing the changes it made to the Original Claims of the '711 Patent. This is found in “Claims Appendix” of the Motion to Amend. These changes are shown below with the added limitations underlined.

61. Substitute Claim 21:

[[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 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.

62. Substitute Claim 22:

22. The method of claim 21, wherein the reference aerial vehicle is a multirotor unmanned aerial vehicle and the target is an aerial vehicle.

63. Substitute Claim 23:

23. The method of claim 21, wherein performing the flight control operation includes one or more of the following: turning the reference aerial vehicle towards the target,

adjusting a speed of the reference aerial vehicle, or engaging a mechanism to capture the target.

64. Substitute Claim 24:

24. The method of claim 21, wherein detecting the target in the image including by applying at the reference aerial vehicle the machine learning model to the image includes identifying a model type of the target based on the classification of the detected target.

65. Substitute Claim 25:

~~[[8]]~~25. The method of claim ~~[[7]]~~21 wherein performing the flight control operation includes determining a speed adjustment factor based on the determined distance to the target.

66. Substitute Claim 26:

~~[[9]]~~26. The method of claim 21, wherein determining the three-dimensional relative location of the target includes determining a direction of the target with respect to the reference aerial vehicle.

67. Substitute Claim 27:

[[10]27. The method of claim 21, wherein determining the three-dimensional relative location of the target includes determining an azimuth angle and an altitude angle to the target from the reference aerial vehicle.

68. Substitute Claim 28:

[[11]]28. The method of claim 21, wherein determining the three-dimensional relative location of the target includes converting a two-dimensional vector to a three-dimensional vector representing the three-dimensional relative location.

69. Substitute Claim 29:

[[12]29.[pre] The method of claim 21, further comprising:

[29.a] receiving a geographical location associated with the target detected at least in part using a ground-based sensor;

[29.b] autonomously navigating the reference aerial vehicle towards the received geographical location; and

[29.c] determining to allow image-based navigation.

70. Substitute Claim 30:

[[13]]30. The method of claim 21, wherein the speed adjustment factor is greater for a smaller magnitude of deviation as compared to for a greater magnitude of deviation.

71. Substitute Claim 31:

[[14]]31. The method of claim 21, wherein performing the flight control operation includes scaling a speed adjustment factor to smooth and limit a rate of change of a speed of the reference aerial vehicle.

72. Substitute Claim 32:

[[15]]32. The method of claim 21, wherein performing the flight control operation includes determining a direction 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.

73. Substitute Claim 33:

[[16]]33. The method of claim [[15]]21, wherein performing the flight control operation includes scaling the direction adjustment factor to smooth and limit a rate of change of a direction of the reference aerial vehicle.

74. Substitute Claim 34:

[[17]]34. The method of claim 21, wherein the distance to the target is determined based at least in part using a radar.

75. Substitute Claim 35:

[[18]]35. The method of claim 21, wherein it is determined to allow the image-based navigation based on whether the reference aerial vehicle is within a threshold distance away from the received geographical location.

76. Substitute Claim 36:

[[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 a target in the image; and

[36.b2] determine 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 using 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 using 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.

77. Substitute Claim 37:

[[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 an image captured by an image sensor of the reference aerial vehicle;

[37.b] 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;

[37.c] 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

[37.d] 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[.],

[37.e1] wherein the detecting of the target comprises: determining a confidence level for the detection of the target, and

[37.e2] using a first neural network having a first robustness and a first refresh rate, or a second neural network having a second robustness and a second refresh rate, the first robustness being greater than the second robustness and the first refresh rate being smaller than the second refresh rate, and

[37.e3] wherein the first neural network is used when the confidence level is below a given threshold and the second neural network is used when the confidence level is above the given threshold.

XII. PRIORITY DATE OF THE SUBSTITUTE CLAIMS

78. I note that the Petition argued, and the Board acknowledged, that the claims of the '711 Patent are not entitled to a priority date of October 9, 2016, and Petitioner assumes a priority date of October 1, 2017. [Pet. at 3-4; Institution Decision (Paper 16) at 11-12.] I further note that Patent Owner did not contest Petitioner's priority date contention in the MTA or the Patent Owner's Response (Paper 20). Furthermore, Patent Owner concedes priority by citing only to the '711 Patent's underlying application as alleged support for the SCs. [MTA at 2-24 (citing to support only in the "'452 App.")]

79. As the Substitute Claims suffer from the same issues identified for the original claims, I understand that the Substitute Claims are also not entitled to a priority date of October 9, 2016. I thus assume a priority date of October 1, 2017 for the Substitute Claims. However, I do not concede that the Substitute Claims are necessarily entitled to this October 1, 2017 date, application 15/729,581's filing date, or that the Substitute Claims are supported by application 16/142,452.

XIII. CLAIM CONSTRUCTION

80. I have been informed by counsel for Petitioner that the challenged claims of the '711 Patent are to be given their ordinary and customary meaning as understood by one of ordinary skill in the art at the time of the invention in light of

the specification and the prosecution history pertaining to the patent. I also understand, however, that a claim term will not receive its ordinary meaning if the patentee acted as his own lexicographer and clearly set forth a definition of the claim term in the specification. In such a case, the claim term will receive the definition set forth in the patent. I have followed these principles in my analysis set forth in this Declaration.

81. To the extent the Applicant has expressly defined a claim term in the specification, I have used that definition. With respect to claim terms for which the applicant has not provided an express definition, I have applied the ordinary and customary meaning of the claim terms in light of the specification and the prosecution history in my analysis of the claims and the prior art herein.

82. I note that Patent Owner has proposed a POSITA definition that differs from what I proposed. [MTA at 1-2.] I do not agree with this definition of a POSITA. However, I qualify under this definition of a POSITA. And under this definition or the definition I applied in the Petition (which is correct), my determinations are the same.

XIV. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE

A. OBVIOUSNESS

83. Based upon my review of the Petition, the Motion to Amend, the materials cited in my Original Declaration and this Second Declaration, and the

materials listed in the LIST OF EXHIBITS above, it is my opinion that Substitute Claims 21-37 of the '711 Patent are rendered obvious by the Grounds listed in the table below:

Ground	Substitute Claim(s)	Basis 35 U.S.C. §	Prior Art
23	21-27, 29, 31-33, 35	103	Beard, Laufer, Pierce, Khan, Kumar
24	28	103	Beard, Laufer, Malecki, Pierce, Khan, Kumar
25	30	103	Beard, Laufer, Sahasrabudhe, Pierce, Khan, Kumar
26	34	103	Beard, Laufer, Hogasten, Pierce, Khan, Kumar
27	36	103	Beard, Laufer, Pierce, Ning
28	37	103	Beard, Laufer, Pierce, Park, Redmon
29	21, 23-26, 32	103	Pierce, Kumar, Khan, Beard
30	22, 29, 35	103	Pierce, Kumar, Khan, Beard, Laufer
31	34	103	Pierce, Kumar, Khan, Beard, Hogasten
32	36	103	Pierce, Kumar, Ning, Beard
33	37	103	Pierce, Kumar, Park, Redmon, Beard
34	21, 23-26, 31-33	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe
35	22, 29, 35	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe, Laufer
36	34	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe, Hogasten
37	36	103	Pierce, Kumar, Sahasrabudhe, Ning
38	37	103	Pierce, Kumar, Sahasrabudhe, Park, Redmon

84. I provide a summary of the grounds below.

85. Grounds 23-26 rely on original grounds 1-6 from the Petition and add Pierce (EX1005), Khan (EX1021), and Kumar (EX1007).

86. Grounds 27 and 28 rely on original ground 1 from the Petition and add (1) Pierce and Ning (EX1034) or (2) Pierce, Park (EX1035), and Redmon (EX1036), respectively.

87. Grounds 29-31 rely on original grounds 7-14 from the Petition and adds Kumar and/or Khan and Beard (EX1009).

88. Grounds 32 and 33 rely on original grounds 7 and 8 and add Ning and Beard or Park, Redmon, and Beard.

89. Grounds 34-36 rely on original grounds 15-22 and add Kumar and/or Khan and Beard.

90. Grounds 37 and 38 rely on original grounds 15 and 16 and add Ning or Park and Redmon.

91. Khan was used in original grounds 2, 11, 12, 19, and 20 of the Petition, Kumar was used in original grounds 3, 8, 10, 12, 14, 16, 18, 20, and 22, Beard was used in original grounds 1-6, and Pierce was used in original grounds 7-22, and each of these references is prior art to and in the same field of endeavor of the '711 Patent, as the Petition demonstrated. [Pet at 4-7.]

92. Ning (EX1034), Park (EX1035), and Redmon (EX1036) are from the same field of endeavor as the '711 Patent and reasonably pertinent to the problem

the patent was trying to solve as well. [EX1034, Abstract, 4:29-5:3, 6:4-14, 11:1-3, 12:55-13:16; EX1035, Abstract, pp. 124-127; EX1036, Abstract, p. 779; Pet. at 6-7.]

93. Ning (filed May 11, 2016, published Sept. 12, 2017) is prior art under §§102(a)(1), (a)(2). [EX1034.]

94. Park (published January 20, 2016) is prior art under §102(a)(1). [EX1035; EX1037.]

95. Redmon (published February 6, 2017) is prior art under §102(a)(1). [EX1036; EX1037.]

B. LACK OF WRITTEN DESCRIPTION

96. It is additionally my opinion that Substitute Claims 21-37 are invalid for lack of written description because the specification of the '711 Patent has not been shown to reasonably convey to a POSITA that the inventor had possession of the claims.

97. It is additionally my opinion that Substitute Claim 36 is invalid for lack of written description because the specification of the '711 Patent does not reasonably convey to a POSITA that the inventor had possession of a first neural network that performs object detection, and a second neural network that performs incrementally predicting a three-dimensional relative location.

98. It is additionally my opinion that Substitute Claim 24 is invalid for lack of written description because the specification of the '711 Patent does not reasonably convey to a POSITA that the inventor had possession of “identifying a model type of the target based on the classification of the detected target.”

99. It is additionally my opinion that Substitute Claim 25 is invalid for lack of written description because the specification of the '711 Patent does not reasonably convey to a POSITA that the inventor had possession of performance of a “flight control operation” including determining two “speed adjustment factors;” one based on a “magnitude of deviation of a direction,” and another based on “the determined distance.

100. It is additionally my opinion that Substitute Claim 31 is invalid for lack of written description because the specification of the '711 Patent does not reasonably convey to a POSITA that the inventor had possession of performance of a “flight control operation” involving two “speed adjustment factors;” one that is based on a “magnitude of deviation of a direction,” and another that is scaled.

101. It is additionally my opinion that Substitute Claim 32 is invalid for lack of written description because the specification of the '711 Patent does not reasonably convey to a POSITA that the inventor had possession of determining both a “speed adjustment factor” and a “direction adjustment factor,” which are both required by Substitute Claim 32.

102. It is additionally my opinion that the Substitute Claims are invalid for lack of written description for any additional reasons I state in the relevant section below.

C. LACK OF ENABLEMENT

103. It is further my opinion that Substitute Claims 21-37 are invalid as not enabled because the specification does not inform a POSITA how to make and use the full scope of the invention without undue experimentation. Specifically, the specification does not inform a POSITA regarding “speed adjustment factor,” “first robustness and a first compute cost” and “a second robustness and a second compute cost,” and “a first robustness and a first refresh rate” and “a second robustness and a second refresh rate,” recited in one or more of Substitute Claims 21, 36, and 37 (and thus required by their dependent claims).

104. It is additionally my opinion that the Substitute Claims are invalid for lack of enablement for any additional reasons I state in the relevant section below.

D. INDEFINITENESS

105. It is further my opinion that Substitute Claims 21-37 are invalid as indefinite because a POSITA lacks reasonable certainty as to the scope of “a speed adjustment factor,” “first robustness,” “second robustness,” “first compute cost,” “second compute cost,” “first refresh rate,” and “second refresh rate,” recited in one

or more of Substitute Claims 21, 36, and 37 (and thus required by their dependent claims).

106. It is further my opinion that Substitute Claim 21-35 are invalid as indefinite at least because a POSITA lacks reasonable certainty as to the scope of “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” recited in Substitute Claim 21 (and thus required by their dependent claims).

107. It is further my opinion that Substitute Claims 24, 25, 31, and 33 are invalid as indefinite as discussed in more detail below.

108. It is additionally my opinion that the Substitute Claims are invalid for indefiniteness for any additional reasons I state in the relevant section below.

XV. THE SUBSTITUTE CLAIMS ENLARGE CLAIM SCOPE

109. In the MTA, Patent Owner amended dependent Substitute Claim 33 (original dependent claim 16) to depend directly from independent Substitute Claim 21 rather than on intervening dependent Substitute Claim 32 (original dependent claim 15). [MTA at 17.] In my opinion, this amendment broadens Substitute Claim 33 as the claim no longer requires “wherein performing the flight control operation ...” recited by Substitute Claim 32 (original claim 15). [*Id.*]

XVI. THE SUBSTITUTE CLAIMS LACKS WRITTEN DESCRIPTION SUPPORT

A. SUBSTITUTE CLAIMS 21-37

110. I note that Patent Owner asserts written description support by citing to a string of alleged “relevant portions” of the ’711 Patent’s underlying application (EX2019) and corresponding portions of the ’711 Patent (EX1001). [MTA at 3-24.] However, these portions do not demonstrate support for the Substitute Claims (SCs). The Patent Owner’s brief accompanying commentaries regarding these portions mischaracterize the disclosures and fails to explain how the citations are supportive to the issue of written description. In my opinion, Patent Owner has not met its burden to properly show how the Substitute Claims are supported. I identify specific instances of lack of written description support below.

B. INDEPENDENT SUBSTITUTE CLAIM 36: ELEMENT [36.D]

111. Element [36.d] recites “wherein the detecting of the target in the image is performed using a first neural network...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 using a second neural network...”

112. Thus, to satisfy the written description requirement, I understand that Patent Owner must show that the original specification describes a *first* neural network that performs the task of object detection, and a *second* neural network that performs the task of incrementally predicting the 3-D relative location. Patent Owner

cannot meet this burden for at least two reasons. First, Patent Owner relies on a combination of disparate paragraphs that appears to rely on obviousness to show possession of element 36.d. Patent Owner lists unexplained citations from paragraphs 34, 109, 110, 113, 121, 145, 151, and 152 of the '711 underlying application—which in my opinion highlights Patent Owner’s attempt to show support by relying on obviousness from the disclosures.

113. Additionally, the cited paragraphs fail to support element 36.d as a whole. Patent Owner’s primary support rests on paragraph 110. This paragraph does not provide adequate support. It describes using a “reduced resource background tracker” to predict “the location.” However, it never states that this “background tracker” is a “second neural network” as element 36.d requires. A generic tracker is not a neural network and could be implemented in many other ways. I also note that paragraph 110 only mentions predicting “the location;” it does not mention predicting “the *three-dimensional relative* location” as required by the SCs.

114. Patent Owner also cites paragraphs 145, 146, 150, and 151 of the '711 underlying application. These paragraphs fare no better in my opinion. Paragraph 146 explicitly limits these processing schemes to object detection. They are not for 3D relative location prediction. Nothing in paragraphs 145, 146, 150, or 151 (or any of the other relied-upon cites) associates one neural network with object detection and a completely different neural network with the incremental prediction of the 3D

relative location. The specification does not describe the bifurcated, dual-network architecture that Patent Owner now attempts to claim. Thus, in my opinion, because the original specification lacks this disclosure, the proposed amendment introduces new matter and must be rejected.

C. DEPENDENT SUBSTITUTE CLAIM 24

115. Substitute Claim 24 recites: “The method of claim 21, wherein detecting the target in the image including by applying at the reference aerial vehicle the machine learning model to the image includes identifying a model type of the target based on the classification of the detected target.”

116. Patent Owner has not shown support for “identifying a model type of the target *based on the classification of the detected target*.” This language suggests that target classification occurs first and then the model type is identified using the determined classification. Patent Owner cites to ¶¶ 94-95 of the '711 underlying application for this teaching. However, those cites merely describe classifying a target. In my opinion, neither cited portion describes that the identification of “a model type” is *based on* “the classification.”

D. DEPENDENT SUBSTITUTE CLAIM 25

117. Substitute Claim 25 recites: “The method of claim 21 wherein performing the flight control operation includes determining a speed adjustment factor based on the determined distance to the target.”

118. To the extent Patent Owner intended the “speed adjustment factor” of Substitute Claim 25 be different from the “speed adjustment factor” of Substitute Claim 21, Substitute Claim 25 would require that the performance of a “flight control operation” includes determining two “speed adjustment factors.” One speed adjustment factor would be based on a “magnitude of deviation of a direction,” and another speed adjustment factor would be based on “the determined distance.” In my opinion, Patent Owner has not shown support for this concept. [MTA at 6-7, 9-10.] Patent Owner cites to the '711 underlying application at ¶97, claim 8, and Fig. 5, and the '711 Patent at 18:44-64 and Fig. 5. However, these portions, at best, disclose only “a factor based on an associated distance or speed.” The other cited portions are also deficient in my view because they similarly do not provide adequate support for the claimed concept.

E. DEPENDENT SUBSTITUTE CLAIM 31

119. Substitute Claim 31 recites: “The method of claim 21, wherein performing the flight control operation includes scaling a speed adjustment factor to smooth and limit a rate of change of a speed of the reference aerial vehicle.”

120. To the extent Patent Owner intended for the “speed adjustment factor” of Substitute Claim 31 to be different from the “speed adjustment factor” of Substitute Claim 21, Substitute Claim 31 would require that the performance of a “flight control operation” involves two “speed adjustment factors;” one that is based

on a “magnitude of deviation of a direction,” and another that is scaled. Patent Owner has not shown support for this concept. [MTA at 6-7, 13-14.] In my opinion, at best, Patent Owner’s citations concern scaling a “vector” or scaling a “factor used to control speed.” [*Id.*; EX2019 at ¶¶98-99; ’711 Patent at 18:65-19:44.] In my opinion, Patent Owner has not shown adequate support for this amended claim language.

F. DEPENDENT SUBSTITUTE CLAIM 32

121. Substitute Claim 32 recites: “The method of claim 21, wherein performing the flight control operation includes determining a direction 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.”

122. In my opinion, Patent Owner has not shown support for “determining a direction adjustment factor.” Patent Owner’s citations do not disclose both a “speed adjustment factor” and a “direction adjustment factor,” which are both required as Substitute Claim 32 depends on Substitute Claim 21. [MTA at 6-10, 14.]

XVII. THE SUBSTITUTE CLAIMS ARE NOT ENABLED

A. SUBSTITUTE CLAIMS 21-37 ARE NOT ENABLED

1. **Independent Substitute Claim 21: Element [21.d],**
Independent Substitute Claim 36: Element [36.c],
Independent SC 37: Element [37.c],

123. Element [21.d] recites in part “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” [MTA at 6-7 (emphasis added).]

124. Elements [36.c] and [37.c] of Independent Substitute Claims 36 and 37, respectively, require similar limitations. [MTA at 17-18, 20.]

125. In my opinion, substitute Independent Claims 21, 36, and 37 are not enabled because the ’711 Patent does not explain or suggest what a “speed adjustment factor” is, and a POSITA would not have understood from the ’711 Patent what constitutes this term.

126. The claims, specification, and figures of the ’711 Patent do not shed any light on what this term means. The claims simply recite that the term is “determine[] [ed],” but that does not explain its meaning. Regarding the specification, Patent Owner cites to various portions of it in the MTA to show alleged written description support, but they do not provide clarity as to the meaning of “speed adjustment factor.” [MTA at 6-7.] Specifically, the underlying application of the ’711 Patent at ¶¶34, 59, and Figs. 3A-3B, and the ’711 Patent at 3:41-42, 9:38-47, and Figs 3A-3B, do not refer to a “speed adjustment factor.” Instead, they generically discuss flight control and how a UAV is controlled to fly at a certain speed. EX2019 at ¶¶97-99 and Fig. 5, and EX1001 at 18:44-59, 18:65-19:1, 19:4-

20, and Fig. 5, also do not provide sufficient detail on the meaning of a “speed adjustment factor.”

127. The underlying application of the ’711 Patent at ¶¶99 and the ’711 Patent at 19:4-20 both mention “[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” and that “the speed and/or acceleration factor is multiplied by one or more scalar values.” However, none of these sections explain the meaning of “speed adjustment factor” or what this “factor” entails. At best, they indicate a way in which the factor might be used. Similarly, the prosecution history does not provide any further insight into the term’s meaning.

128. A POSITA would have understood that to provide “performing the flight control operation,” a speed adjustment factor would have needed to be determined. But a POSITA having read the specification would be left guessing how a speed adjustment factor is actually determined, or what constitutes this term. Given the Patent Owner added the limitations that recite “speed adjustment factor” to the independent claims during prosecution (EX1002 at 215-229), it thus considers them to be novel aspects of the alleged invention. However, because the meaning of these terms is not adequately disclosed in the specification, the Substitute Claims 21, 36, and 37 fail to comply with the enablement requirement.

129. Further, a POSITA would not know how to determine such 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," as required. The '711 Patent simply does not describe a method for determining any factor based on such a criteria.

130. Given the specification's failure to identify any criteria for what constitutes a "speed adjustment factor," nor how to determine any such a factor, a POSITA at the time of the claimed invention would not have been able to make and use the claimed invention of Substitute Independent Claims 21, 36, and 37 without undue experimentation. The specification does not provide any direction or guidance on the meaning of "speed adjustment factor" as discussed, and further provides no working examples of how the terms are determined. The technology of autonomously flying an aerial vehicle in pursuit of another aerial vehicle is highly unpredictable art. As such, it would require undue experimentation to develop an appropriate "speed adjustment factor," especially one that is determined "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." Additionally, the usage of "speed adjustment factor" in Substitute Independent Claims 21, 36, and 37 is broad. Due to the specification's lack of disclosure, the breadth of claim scope contemplated by using this term is not enabled.

131. As such, Substitute Independent Claims 21, 36, and 37 are not enabled.

2. **Independent Substitute Claim 36: Element [36.d]**

132. Element [36.d] recites “wherein the detecting of the target in the image is performed using 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 using 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**.” [MTA at 18-19 (emphasis added).]

133. In my opinion, independent Substitute Claim 36 is not enabled because the ’711 Patent does not explain or suggest what a “robustness” and “compute cost” are, and a POSITA would not have understood from the ’711 Patent what constitutes these terms.

134. The claims, specification, and figures of the ’711 Patent do not shed any light on what these terms mean. The claims simply recite them as characteristics of neural networks (i.e., “first neural network at a first robustness and a first compute cost,” “second neural network at a second robustness and a second compute cost”) that are relative to each other (i.e., “first robustness and the first compute cost being

greater, respectively, than the second robustness and the second compute cost”). None of this explains what constitutes a “robustness” or “compute cost.”

135. The specification does not fare any better because it too simply uses the terms “robustness” and “compute cost” without explaining their meaning. The specification explains that there is a relationship between algorithm “robustness” and the “cost and/or latency of the algorithm per spacio-temporal frame,” and that various tracking algorithms provide “robustness at a high compute cost” or a “low compute cost and average robustness.” [’711 Patent, 21:52-57, 22:3-10.] None of this explains, however, what an algorithm “robustness” or “compute cost” is or means. The specification also notes that “algorithms may differ in their effectiveness based on the type of input received,” 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,” and that algorithms can have various costs and robustness (e.g. “high,” “medium,” “low”). [*Id.*, 27:43-28:10, 28:40-29:3.] However, other than suggesting that “robustness” relates to inputs provided to an algorithm, and that a robustness and cost of algorithms can each be relative, this explanation also fails to provide any meaning to the terms “robustness” and “compute cost.” The prosecution history does not provide any further insight into the meaning of these terms.

136. A POSITA would have understood that in order for “the first robustness and the first compute cost” to be “greater, respectively, than the second robustness and the second compute cost,” the first and second robustness and compute cost would need to be known and measurable. But a POSITA having read the specification would be left guessing how robustness or compute cost is actually determined, or what constitutes these terms. As Patent Owner added the limitations that recite “robustness” and “compute cost” in its MTA, it thus considers them to be novel aspects of the alleged invention. However, because the meaning of these terms is not adequately disclosed in the specification, the Substitute Claim 36 fails to comply with the enablement requirement.

137. In order to practice the limitations including “robustness” and “compute cost”, one must measure the quantities first so that they can satisfy the requirement of having “first robustness and the first compute cost being greater, respectively, than the second robustness and the second compute cost.” The claims, the specification, and the prosecution history are silent on how to measure these qualities in a way that enables their comparison.

138. Given the specification’s failure to identify any criteria for what constitutes a “robustness” or “compute cost,” nor how to measure any such qualities, a POSITA at the time of the claimed invention would not have been able to make and use the claimed invention of Substitute Independent Claim 36 without undue

experimentation. The specification does not provide any direction or guidance on the meaning of “robustness” or “compute cost” as discussed above, and further provides no working examples of how the terms are determined. The technology of autonomously flying an aerial vehicle in pursuit of another aerial vehicle while automatically processing video streams of suspected targets is highly unpredictable art. As such, it would require undue experimentation to develop a measurable process for defining “robustness” or “compute cost” for use in the claimed application. Additionally, the usage of “robustness” and “compute cost” in Substitute Independent Claim 36 is broad. Due to the specification’s lack of disclosure, the breadth of claim scope contemplated by using these terms is not enabled.

139. As such, Substitute Independent Claim 36 is not enabled.

3. Independent Substitute Claim 37: Element [37.e2]

140. Element [37.e2] recites “wherein using a first neural network having a **first robustness** and a **first refresh rate**, or a second neural network having a **second robustness** and a **second refresh rate**, the **first robustness** being greater than the **second robustness** and the **first refresh** rate being smaller than the **second refresh rate**.” [MTA at 22-23 (emphasis added).]

141. In my opinion, independent Substitute Claim 37 is not enabled because the ’711 Patent does not explain or suggest what a “robustness” and “refresh rate”

are, and a POSITA would not have understood from the '711 Patent what constitutes these terms.

142. The claim is not enabled due to its use of “robustness” for the same reasons discussed previously in Section XVII.A.2.

143. With respect to the term “refresh rate,” the claims, specification, and figures of the '711 Patent do not shed any light on what this term means. The claims recite a “refresh rate” as a characteristic of neural networks, where the rates of the “first neural network” and “second neural network,” respectively, are relative to each other. But this does not explain what constitutes a “refresh rate.” And the specification is also insufficient. The specification states that algorithms can have a “low refresh rate” or a “high refresh rate,” and that refresh rates for certain algorithms can be “higher,” simply using the term without explaining its meaning. [’711 Patent, 27:43-28:47.] The prosecution history also does not provide any further insight into the meaning of these terms.

144. A POSITA would have understood that for “the first refresh rate” to be “smaller than the second refresh rate,” the first and second refresh rates would need to be known and measurable. However, a POSITA having read the specification would be left guessing how a refresh rate is actually determined, or what constitutes this term. As Patent Owner added the limitations that recite “refresh rate” in its MTA, it thus considers them to be novel aspects of the alleged invention. However,

because the meaning of these terms is not adequately disclosed in the specification, Substitute Claim 37 fails to comply with the enablement requirement.

145. In order to practice the limitations including “refresh rate,” one must measure “refresh rate” first so that it can satisfy the requirement of having “the first refresh rate being smaller than the second refresh rate.” The claims, the specification, and the prosecution history are silent on how to measure “refresh rate” in a way that enables its comparison from one neural network to another neural network.

146. Given the specification’s failure to identify any criteria for what constitutes a “refresh rate,” nor how to measure it, a POSITA at the time of the claimed invention would not have been able to make and use the claimed invention of Substitute Independent Claim 37 without undue experimentation. The specification does not provide any direction or guidance on the meaning of “refresh rate” as discussed, and further provides no working examples of how the term is determined. The technology of autonomously flying an aerial vehicle in pursuit of another aerial vehicle while processing video streams of suspected targets is highly unpredictable art. As such, it would require undue experimentation to develop a measurable process for defining “refresh rate” for use in the claimed application. Additionally, the usage of “refresh rate” in Substitute Independent Claim 37 is broad. Due to the specification’s lack of disclosure, the breadth of claim scope contemplated by using this term is not enabled.

147. As such, Substitute Independent Claim 37 is not enabled.

4. Dependent Substitute Claims 22-35

148. Dependent Substitute Claims 22-35 are not enabled for the same reasons discussed with respect to Dependent Substitute Claim 21, from which they depend.

149. Dependent Substitute Claims 25, 31, and 32 are also not enabled for at least the same reasons discussed in Section XVI.D, E, and F. Specifically, because these claims do not have adequate written description support and fail to describe embodiments that cover the arrangements of these claims, the specification does not teach a POSITA how to make and use the full scope of their claimed inventions without undue experimentation. [*Id.*]

XVIII. THE SUBSTITUTE CLAIMS ARE INDEFINITE

A. INDEPENDENT SUBSTITUTE CLAIM 21: ELEMENT [21.B]

150. Element [21.b] recites: “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.”

151. In my opinion, element [21.b] renders claim 21 indefinite because this element’s meaning is open to multiple different interpretations. It would have been unclear to a POSITA whether the claim requires (1) that “detecting...a target in the

image” is performed “to identify a bounding box...” and “to identify a classification” or (2) “applying...a machine learning model to the image” is performed “to identify a bounding box...” and “to identify a classification.” [MTA at 4-5.]

B. INDEPENDENT SUBSTITUTE CLAIM 21: ELEMENT [21.D], INDEPENDENT SUBSTITUTE CLAIM 36: ELEMENT [36.C], AND INDEPENDENT SUBSTITUTE CLAIM 37: ELEMENT [37.C]

152. Element [21.d] recites in part “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” [MTA at 6-7 (emphasis added)].

153. Elements [36.c] and [37.c] of Independent Substitute Claims 36 and 37, respectively, include similar recitations. [MTA at 17-18, 20.]

154. In my opinion, claims 21, 36, and 37 are indefinite because the term “speed adjustment factor” is ambiguous and injects unbounded uncertainty in the meaning of the claims. It is unclear from the specification, and prosecution history what a “speed adjustment factor” actually is, as discussed above in Section XVII.A.1. The ’711 Patent uses the term “speed adjustment factor;” however, it does not say what it is. Therefore, a POSITA would not know the boundaries of what a “speed adjustment factor” is intended to represent. Its usage in elements [21.d],

[36.c], and [37.c], therefore, renders Substitute Independent Claims 21, 36, and 37 indefinite.

C. DEPENDENT SUBSTITUTE CLAIMS 22-35

155. Because independent Substitute Claim 21 is indefinite, dependent Substitute Claims 22-35 are also indefinite. Dependent Substitute Claims 24, 25, 31, and 33 are also indefinite for at least the following reasons.

1. Claim 24

156. Dependent Substitute Claim 24 is indefinite because there is no antecedent basis for “the machine leaning model.”

2. Claim 25

157. Dependent Substitute Claim 25 is indefinite because it is unclear whether the recited “speed adjustment factor” of Dependent Substitute Claim 25 is the same or different from the “speed adjustment factor” previously recited in Independent Substitute Claim 21, on which this claim depends. [MTA at 6-7, 9-10.]

3. Claim 31

158. Dependent Substitute Claim 31 is indefinite because it is unclear whether the recited “speed adjustment factor” of Dependent Substitute Claim 31 is the same or different from the “speed adjustment factor” previously recited in Independent Substitute Claim 21, on which this claim depends. [MTA at 6-7, 13-14.]

4. Claim 33

159. Substitute Dependent Claim 33 is indefinite because “the direction adjustment factor” lacks antecedent basis. [MTA at 3-6, 14-15.]

D. INDEPENDENT SUBSTITUTE CLAIM 36: ELEMENT [36.D]

160. Element [36.d] recites “wherein the detecting of the target in the image is performed using 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 using 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**.” [MTA at 18-19 (emphasis added).]

161. In my opinion, independent Substitute Claim 36 is indefinite because the terms “first robustness,” “second robustness,” “first compute cost,” and “second compute cost” of element [36.d] are ambiguous and injects unbounded uncertainty in the meaning of the claim. It is unclear from the specification, and prosecution history what a “robustness” or “compute cost” actually are. Patent Owner cites to various portions of the ’711 Patent in the MTA that allegedly provide written description support for these terms; however, they do not provide clarity as to the meaning of “robustness” and “compute cost.” [Section XVII.A.2, *supra*.] The ’711 Patent uses the terms but does not say what they mean. Therefore, a POSITA would

not know the boundaries of what these terms are intended to represent. Their usage in element [36.d], therefore, renders Substitute Independent Claim 36 indefinite.

A. INDEPENDENT SUBSTITUTE CLAIM 37: ELEMENT [37.E2]

162. Element [37.e2] recites “wherein using a first neural network having a **first robustness** and a **first refresh rate**, or a second neural network having a **second robustness** and a **second refresh rate**, the **first robustness** being greater than the **second robustness** and the **first refresh** rate being smaller than the **second refresh rate**.” [MTA at 22-23 (emphasis added).]

163. Independent Substitute Claim 37 is indefinite because the terms “first robustness,” “second robustness,” “first refresh rate,” and “second refresh rate” of element [37.e2] are ambiguous and injects unbounded uncertainty in the meaning of the claim. It is unclear from the specification, and prosecution history what a “robustness” or “refresh rate” actually are. Patent Owner cites to various portions of the ’711 Patent in the MTA that allegedly provide written description support for these terms, but they do not provide clarity as to the meaning of “robustness” and “refresh rate.” [Section XVII.A.3, *supra*.] The ’711 Patent uses the terms; however, it does not say what they mean. Therefore, a POSITA would not know the boundaries of what these terms are intended to represent. Their usage in element [37.e2], therefore, renders Substitute Independent Claim 37 indefinite.

XIX. THE SUBSTITUTE CLAIMS ARE OBVIOUS

164. In my opinion, the Substitute Claims would have been obvious under 35 U.S.C. §103. In the grounds below, I address the limitations from the Substitute Claims added by Patent Owner in the MTA and certain other relevant limitations. Limitations from the original claims not addressed below are addressed in the Petition and in my original declaration. I note that elements that are indefinite, lack enablement, and/or lack written description support are addressed based on my understanding of PO's position and as best understood by a POSITA.

165. Grounds 23-26 rely on original grounds 1-6 from the Petition and add Pierce (EX1005), Khan (EX1021), and Kumar (EX1007).

166. Grounds 27 and 28 rely on original ground 1 from the Petition and add (1) Pierce and Ning (EX1034) or (2) Pierce, Park (EX1035), and Redmon (EX1036), respectively.

167. Grounds 29-31 rely on original grounds 7-14 from the Petition and adds Kumar and/or Khan and Beard (EX1009).

168. Grounds 32 and 33 rely on original grounds 7 and 8 and add Ning and Beard or Park, Redmon, and Beard.

169. Grounds 34-36 rely on original grounds 15-22 and add Kumar and/or Khan and Beard.

170. Grounds 37 and 38 rely on original grounds 15 and 16 and add Ning or Park and Redmon.

171. Khan was used in original grounds 2, 11, 12, 19, and 20 of the Petition, Kumar was used in original grounds 3, 8, 10, 12, 14, 16, 18, 20, and 22, Beard was used in original grounds 1-6, and Pierce was used in original grounds 7-22, and each of these references is prior art to and in the same field of endeavor of the '711 Patent, as the Petition demonstrated. [Pet at 4-7.]

172. Ning (EX1034), Park (EX1035), and Redmon (EX1036) are from the same field of endeavor as the '711 Patent and reasonably pertinent to the problem the patent was trying to solve as well. [EX1034, Abstract, 4:29-5:3, 6:4-14, 11:1-3, 12:55-13:16; EX1035, Abstract, pp. 124-127; EX1036, Abstract, p. 779; EX1001, Abstract, 3:27-45; Pet. at 6-7.]

173. Ning (filed May 11, 2016, published Sept. 12, 2017) is prior art under §§102(a)(1), (a)(2). [EX1034.]

174. Park (published January 20, 2016) is prior art under §102(a)(1). [EX1035; EX1037.]

175. Redmon (published February 6, 2017) is prior art under §102(a)(1). [EX1036; EX1037.]

176. I reproduce a table below that summarizes the grounds, which I also included earlier in my declaration.

Ground	Substitute Claim(s)	Basis 35 U.S.C. §	Prior Art
23	21-27, 29, 31-33, 35	103	Beard, Laufer, Pierce, Khan, Kumar

24	28	103	Beard, Laufer, Malecki, Pierce, Khan, Kumar
25	30	103	Beard, Laufer, Sahasrabudhe, Pierce, Khan, Kumar
26	34	103	Beard, Laufer, Hogasten, Pierce, Khan, Kumar
27	36	103	Beard, Laufer, Pierce, Ning
28	37	103	Beard, Laufer, Pierce, Park, Redmon
29	21, 23-26, 32	103	Pierce, Kumar, Khan, Beard
30	22, 29, 35	103	Pierce, Kumar, Khan, Beard, Laufer
31	34	103	Pierce, Kumar, Khan, Beard, Hogasten
32	36	103	Pierce, Kumar, Ning, Beard
33	37	103	Pierce, Kumar, Park, Redmon, Beard
34	21, 23-26, 31-33	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe
35	22, 29, 35	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe, Laufer
36	34	103	Pierce, Khan, Kumar, Beard, Sahasrabudhe, Hogasten
37	36	103	Pierce, Kumar, Sahasrabudhe, Ning
38	37	103	Pierce, Kumar, Sahasrabudhe, Park, Redmon

A. OVERVIEW OF NING (EX1034)

177. Ning discloses a “vision-centric deep-learning-based” object detection and tracking system. [EX1034, Abstract.] Ning’s system is a “Recurrent You Only Look Once or ROLO” system, where a “You Only Look Once” (or YOLO) object recognition architecture is used in conjunction with “Long short-term memory (LSTM)” object tracking. [EX1034, Abstract, 1:51-2:3, 2:15-19, 2:35-62, 3:3-17, , 5:46-54, 6:15-53, 6:59-8:33, 8:41-9:4, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-

13:2, Figs. 2, 4, 5, 6, 8.] The LSTM is a “type of recurrent neural network (RNN) architecture;” indeed, the ROLO system operates by “connect[ing] 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.*, 4:55-5:3.] Ning’s system is applicable to vehicles in that it “can be amounted on any suitable vehicle.” [*Id.*, 5:35-38.]

B. OVERVIEW OF PARK (EX1035)

178. Park discloses a “big/LITTLE DNN” system in which two different deep neural networks (DNNS) are capable of performing object detection. [EX1035, Abstract.] The first DNN architecture is a “little” architecture that consumes less energy in performing object detection, and the second DNN architecture is a “full-fledged” and “big” architecture that consumes more energy, but provides more accurate results. [*Id.* at 124-131.] The system works by running an image through the “little DNN” and determining a “score margin” formed by a subtraction of the largest and second largest recognition scores for object detection. [*Id.*, 125-126.] If the score margin is above a threshold, then the little DNN’s recognition output is deemed correct and taken as the final result. [*Id.*, 125-127.] However, if the score margin is below the threshold, then the big DNN is applied to the image to determine a final recognition output. [*Id.*]

C. OVERVIEW OF REDMON (EX1035)

179. Redmon discloses “You Only Look Once” (YOLO) object detection techniques. [EX1036, 779.] Redmon teaches use of two different YOLO algorithms: a “base YOLO” that “processes images in real-time at 45 frames per second” and a “Fast YOLO” that is a “smaller version” of the base YOLO and processes images at “155 frames per second.” [*Id.*]

D. GROUND 23: SUBSTITUTE CLAIMS 21-27, 29, 31-33, 35

1. Motivation to Combine

180. A POSITA would have been motivated to combine Beard, Laufer, Pierce, Khan, and Kumar (the “BLPKK combination”). First, a POSITA would have been motivated to combine Beard, Laufer, Khan, and Kumar for the same reasons discussed in the Petition and my original declaration with respect to Beard and Laufer (Pet. at 10-13), Beard, Laufer, and Khan (Pet. at 36-38), and Beard, Laufer, and Kumar (Pet. at 38-41). Moreover, a POSITA 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 neural networks for object detection and tracking. [EX1005, ¶¶0027, 0042, 0044-0046, Figs. 1, 6.] Pierce’s teachings provide explicit implementation details for how a drone utilizes on-board neural networks for object detection and tracking, which furthers Beard, Laufer, Khan, and Kumar’s combined teachings related to such concepts. [*Id.*; Pet. at 10-27, 36-41.] Utilizing Pierce’s teachings would have been applying a known technique

(drone having on-board object identification and tracking capabilities that use neural networks) to improve similar devices (drones that identify and track objects) in the same way (using the on-board object identification and tracking capabilities) [*Id.*] The combination would have yielded the predictable result of Beard's UAV performing on-board object identification and tracking using neural networks. [*Id.*] Moreover, for the same reasons noted above, and given that the combination reflects mere implementation details, and also due to the overlap in subject matter between the references and compatibility of the references, a POSITA would have had a reasonable expectation of success in making the combination. [*Id.*]

2. Claim 21

a) Element [21.a]

181. **Element [21.a]:** “receiving at a processor at the reference aerial vehicle an image captured by an image sensor of the reference aerial vehicle;”

182. The BLPKK combination teaches Beard's image processor 234 “aboard UAV 100” receives and analyzes images captured by camera 210 and image sensor 212 that are also aboard UAV 100 (*receiving at a processor at the reference aerial vehicle an image...*). [Petition at 10-16; EX1009, 3:57-4:21, 7:13-53, Fig. 5.]

b) Element [21.b]

183. **Element [21.b]:** “[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;

184. **Pierce** teaches a “drone system 600 [that] may be drone 102,” where the system 600 includes an “object tracking module 615.” [EX1005, ¶¶0027, 0042, 0044-0046, Figs. 1, 6.] Images of the “surrounding area” of the drone may include objects “such as a moving target,” and the object tracking module 615 on board the drone implements “various neural networks” that analyze the images “to identify and track the moving target, and thereby estimate its position and velocity from [the] drone.” [*Id.* at ¶0045, Fig. 6.]

185. **Khan** discloses a “method and a digital processing system for real-time or near-real-time automatic video classification of vehicle model types in aerial imagery.” [EX1021, ¶0003.] Khan discloses an “on-board computing platform 114,” located on-board a UAV 100, that is used to implement “detecting and classifying types of vehicle models in aerial imagery captured by one or more image capturing devices 106 associated with the UAV 100.” [*Id.*, ¶¶0037-0039.] Khan’s computer processes captured images 700 by determining “salient features of a vehicle 702 in the captured images 700,” where the features are “shape and appearance” features at feature locations 804, 806, and 808, and are located within a bounding box surrounding vehicle 702 as shown by Figures 7 and 8. [*Id.*, 0045-0050, Figs. 7-8.] These detected features of the vehicle 702 are then compared to corresponding 3D

vehicle model features at the same location to determine an “appropriate classification” of the vehicle. [*Id.*, ¶¶0045-0063.] For example, the vehicle is classified into a vehicle type such as a “full sedan, mid sedan, compact sedan, station wagon, van, SUV, compact/crossover SUV, and truck.” [*Id.*, ¶¶0044, 0062.] Classification may be performed using a “linear classifier” such as a “support vector machine classifier (SVM)” machine learning model. [*Id.*, ¶0062.]

186. Moreover, **Kumar** discloses that “bounding boxes” around “all objects of interest” in an image are output by a neural network. [EX1007, ¶0019; EX1008, ¶0029.] A neural network is a known type of machine learning model. [EX1007, ¶0002; EX1008, ¶0001.]

187. As such, the BLPKK combination teaches Beard’s on board UAV image processor 234 detects a target 118 in image frames by applying a machine learning/neural network algorithm to image frames to “identify potential target objects 112a, 112b, 112c, and 112d,” which can be aircraft, “via bounding boxes 116a, 116b, 116c, and 116d” that each surround a portion of an image including the potential target objects, where a target object is selected as target object 118 (*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*). [Petition at 15-16; EX1009, 3:9-4:21, 4:22-25, 2:2-8, 7:13-53, Figs. 1A-1C, 5; EX1003, ¶¶117-118.]

188. In the combination, by performing the detecting of a target (*detecting at the reference aerial vehicle...*), the identified bounding boxes would have outlined detected “shape and appearance” features of the potential target objects 112 (and thus the determined selected target object 118) as taught by Khan (*to identify a bounding box outlining a portion of the image that includes detected features of the target*). [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7.] Moreover, by performing the detecting of a target (*detecting at the reference aerial vehicle...*), these features would have been used to classify a selected target object 118 as a particular type of target as taught by Khan (*and to identify a classification of the detected target.*) [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7.]

189. Additionally, under an alternative interpretation, Beard’s on board UAV image processor 234 would apply the machine learning/neural network algorithm (*applying at the reference aerial vehicle a machine learning model...*) to generate the identified bounding boxes, and these bounding boxes would have outlined detected “shape and appearance” features of the potential target objects 112 (and thus the determined selected target object 118) as taught by Khan and Kumar (*to identify a bounding box outlining a portion of the image that includes detected features of the target*). [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7; EX1007, ¶¶0002, 0019; EX1008, ¶¶0001, 0029.] Moreover, Beard’s on board UAV image processor 234 applying the machine learning/neural network algorithm (*applying at the*

reference aerial vehicle a machine learning model...) would have classified a selected target object 118 as a particular type of target based on the features as taught by Khan (and to identify a classification of the detected target). [EX1021, 0045-0063, Figs. 6, 7; EX1007, ¶¶0002, 0019; EX1008, ¶¶0001, 0029.]

c) Element [21.c]

190. **Element [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”

191. The BLPKK combination teaches Beard’s on-board UAV image processor 234 determines tracking parameters between the UAV and a target 118 including distance, angle of elevation, and bearing (determining at the reference aerial vehicle a three-dimensional relative location of the target...). [Pet. at 16-18.] Beard further explains this determined distance is “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 116 around a target, calculated by multiplying the bounding box’s width of “ γ pixels” with the bounding box’s height of “ δ pixels” (i.e., “ $\gamma*\delta$ ”), as shown in Figure 1C (determining...a three-dimensional relative location of the

target...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). [Pet. at 16-18, 28-29.]

192. Moreover, Khan teaches classification of a target into a particular type (e.g., an SUV, sedan, etc.) as discussed above for Element [21.b], and Kumar teaches a target tracking system that recognizes a target in captured images and produces a bounding box around the target. [EX1021, ¶¶0003, 0037-0039, 0044-0063, Figs. 7-8; EX1007, ¶¶0020, 0035, Fig. 2; EX1008, ¶¶0018, 0030, Fig. 2.] Kumar's system 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." [EX1007, ¶¶0019-0025, 0037, Fig. 3A; EX1008, ¶¶0018-0023, 0032, claims 4-5, claims 14-15; claims 24-25, Fig. 3A; EX1003, ¶¶157-158.] Thus, Khan teaches classifying a target in an image as a particular type, and Kumar teaches determining a relative position using a physical size of such a type of target. [EX1007, ¶¶0019-0025, 0037, Fig. 3A; EX1008, ¶¶0018-0023, 0032, claims 4-5, claims 14-15; claims 24-25, Fig. 3A; Petition at Section VIII.C; EX1003, ¶¶162-163.]. Therefore, the BLPKK combination teaches that the distance between Beard's UAV 100 and target 118 would further have been based on a physical size (as taught by Kumar) corresponding to the classified type of target object identified in a

captured image (as taught by Khan) (*determining a distance to the target based at least in part on...and on a physical size corresponding to the classification of the target detected within the image*). [EX1007, ¶¶0019-0025, 0037, Fig. 3A; EX1008, ¶¶0018-0023, 0032, claims 4-5, claims 14-15; claims 24-25, Fig. 3A; Petition at Section VIII.C; EX1003, ¶¶162-163.]

d) Element [21.d]

193. **Element [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 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.”

194. Beard describes performing flight control operations, such as controlling the speed of one or more rotors, takes place on board UAV 100 using attitude control system 232 (*performing at the reference aerial vehicle the flight control operation...*). [Pet. at 10-13, 18-27.]

195. Claim 21 is thus obvious.

3. Claim 24

196. Claim 24 recites: “The method of claim 21, wherein detecting the target in the image including by applying at the reference aerial vehicle the machine

leaning model to the image includes identifying a model type of the target based on the classification of the detected target.”

197. Khan teaches type classification of an object in an image, such as an SUV, sedan, van, etc. [EX1021, ¶¶0003, 0037-0039, 0044-0063, Figs. 7-8.] The BLPKK combination thus teaches that the target detection by Beard’s on board UAV image processor 234 applying a machine learning/neural network algorithm to image frames includes identifying a model type (e.g., a vehicle model type such as an SUV, sedan, van, etc.) based on the classification of the target object as a particular model type (*wherein detecting the target in the image including by applying at the reference aerial vehicle the machine leaning model to the image includes identifying a model type of the target based on the classification of the detected target*). [Supra Section XIX.D.1-2; Pet. at 36-38.]

4. Claims 22, 23, 25-27, 29, 31-33, and 35

198. Claims 22, 23, 25-27, 29, 31-33, and 35 depend from claim 21, and are obvious for the same reasons discussed above for claim 21, as well as the same reasons discussed in the Petition for claims 2, 3, 8-10, 12, 14-16, and 18, respectively. [Pet. at 27-43.] The same reasoning there applies to the BLPKK combination.

E. GROUNDS 24, 25, AND 26

199. Beard, Laufer, Pierce, Khan, Kumar, and Malecki is Ground 24.

200. Beard, Laufer, Pierce, Khan, Kumar, and Sahasrabudhe is Ground 25.

201. Beard, Laufer, Pierce, Khan, Kumar, and Hogasten is Ground 26.

202. Substitute Claims 28, 30, and 34 depend from Independent Substitute Claim 21. Grounds 24, 25, and 26 render obvious Substitute Claims 28, 30, and 34, respectively, for the same reasons discussed above regarding Independent Substitute Claim 21, as well as the same reasons discussed in the Petition regarding claims 11, 13, and 17, respectively. [Pet. at 43-50.] Moreover, a POSITA would have been motivated to combine Malecki, Sahasrabudhe, and Hogasten with Beard, Laufer, Pierce, Khan, and Kumar for at least the same reasons discussed in the Petition (Pet. at 43-50), as well as the same reasons discussed above in Section XIX.D.1.

F. GROUND 27: SUBSTITUTE CLAIM 36

1. Motivation to Combine

203. A POSITA would have been motivated to combine Beard, Laufer, Pierce, and Ning (the “BLPN combination”) for the same reasons discussed above with respect to Beard, Laufer, and Pierce. [*Supra* Section XIX.D.1.] Moreover, a POSITA would have been motivated to combine Beard, Laufer, and Pierce with Ning’s teachings of performing object detection using a “You Only Look Once” (YOLO) and object tracking using an LSTM neural network. [EX1034, Abstract, 1:51-2:3, 2:15-19, 2:35-62, 3:3-17, 4:38-5:3, 5:46-54, 6:15-53, 6:59-8:33, 8:41-9:4, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 4, 5, 6, 8; *See supra* Sections

XIX.D.1, XIX.D.2 at Elements [21.b], [21.c]; Pet. at 35-36.] A POSITA would have recognized that Ning’s YOLO and LSTM neural networks provide “real time” object detection and tracking that is “efficient yet accurate.” [EX1034, Abstract, 4:55-58, 5:4-9, 9:18-39; Pet. at 10-13, 35-36.] As such, Ning enhances Beard’s object detection and tracking. [*Id.*] Moreover, the need for “[f]ast, accurate algorithms for object detection” that “allow computers to drive” vehicles was known to POSITAs, and using YOLO, which operates “extremely fast,” was a favorable solution that “generalizes well to new domains, making it ideal for applications that rely on fast, robust object detection” like object recognition and tracking algorithms used by drones. [EX1036, 779, 785-786.] Additionally, Ning’s system “can be amount[ed] on any suitable vehicle” and is thus compatible with the Beard-Laufer-Pierce drone system. [EX1034, 5:35-38.]

204. A POSITA would have thus readily utilized the teachings of Ning with the Beard-Laufer-Pierce drone system, and the combination would have had the predictable result of Beard’s on board UAV image processor 234 detecting a target 118 in image frames by applying a YOLO neural network. [EX1034, Abstract, 1:51-2:3, 2:15-19, 2:35-62, 3:3-17, 4:38-5:3, 5:46-54, 6:15-53, 6:59-8:33, 8:41-9:4, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 4, 5, 6, 8; *See supra* XIX.D.1, XIX.D.2 at Elements [21.b], [21.c]; Pet. at 35-36.] Furthermore, the combination would have had Beard’s on board UAV image processor 234 determining tracking

parameters by using a LSTM neural network to predict and track the location of a target in an analyzed image. [EX1034, Abstract, 1:51-2:3, 2:15-19, 2:35-62, 3:3-17, 4:38-5:3, 5:46-54, 6:15-53, 6:59-8:33, 8:41-9:4, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 4, 5, 6, 8; *See supra* XIX.D.1, XIX.D.2 at Elements [21.b], [21.c]; Pet. at 35-36.] The combination would have had a reasonable expectation of success because YOLO and LSTM were known object detection and tracking techniques well suited for use in vehicle applications due to their speed and ability to provide real-time results. [EX1034, Abstract, 1:51-2:3, 2:15-19, 2:35-62, 3:3-17, 4:38-5:3, 5:46-54, 6:15-53, 6:59-8:33, 8:41-9:4, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 4, 5, 6, 8; EX1036, 779, 785-786.]

2. Claim 36

a) Elements [36.b1], [36.b2], [36.c]

205. **Elements [36.b1]:** “a processor configured to: detect a target in the image; and”

206. **Element [36.b2]:** “determine a three-dimensional relative location of the target with respect to the reference aerial vehicle based on the image; and”

207. **Element [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.”

208. The BLPN combination teaches Beard’s on-board UAV image processor 234 detects a target 118 in image frames by applying a machine learning/neural network algorithm to image frames and determines tracking parameters between the UAV and a target including distance, angle of elevation, and bearing (*processor configured to: detect a target in the image; and determine a three-dimensional relative location...*). [See *supra* XIX.D.2 at Elements [21.b], [21.c]; Pet. at 35-36.] Moreover, attitude control system 232 aboard the UAV performs flight control operations such as controlling the speed of one or more UAV rotors (*a flight controller configured to perform a flight control operation...*). [See *supra* Section XIX.D.2 at Element [21.d]; Section XIX.F.1; Pet. at 35-36.]

b) Element [36.d]

209. **Element [36.d]:** “[36.d] wherein the detecting of the target in the image is performed using 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 using 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.”

210. The BLPN combination teaches Beard’s on board UAV image processor 234 detection of target 118 in image frames is by applying a “You Only Look Once” (“YOLO”) neural network having a high robustness and high compute cost (*“wherein the detecting of the target in the image is performed using a first neural network at a first robustness and a first compute cost”*). [EX1034, Abstract, 1:51-2:3, 2:35-57, 3:3-6, 4:38-54, 5:46-54, 6:15-43, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 8; *See supra* Sections XIX.D.1, XIX.D.2 at Elements [21.b], [21.c]; Section XIX.F.1; Pet. at 35-36.] The ’711 Patent acknowledges that YOLO neural networks have a “high robustness” and “high cost.” [’711 Patent, 27:54-56, 28:40-47.] Moreover, high cost and high robustness processing schemes are explained by the ’711 patent as being those that “produce an object location estimation independent of historical information.” [’711 Patent, 27:54-56.] That is just what Ning’s YOLO neural network does because it performs object location estimates based only on the current full image being analyzed. [EX1034, Abstract, 1:51-2:3, 2:35-57, 3:3-6, 4:38-54, 5:46-54, 6:15-43, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 8; EX1036, 779-780, Figs. 1-2 (discussing YOLO operating on a single input image).]

211. The BLPN combination further teaches Beard's on board UAV image processor 234 determines tracking parameters by using a "long short-time memory" (LSTM) neural network at a medium/low robustness and medium/low compute cost to predict and track the location of a target in an analyzed image, where the prediction is continually updated (*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 using a second neural network at a second robustness and a second compute cost*). [See *supra* Sections XIX.D.1, XIX.D.2 at Elements [21.b], [21.c]; Pet. at 35-36; EX1034, Abstract, 1:51-2:3, 2:15-19, 2:58-62, 3:10-17, 4:55-5:3, 6:33-53, 6:59-8:33, 8:41-9:4, 10:64-11:13, 12:55-13:2, Figs. 4, 5, 6.] Ning teaches the LSTM neural network "refin[ing]" its predicting and tracking of an object's location, as well as repeating its predicting and tracking of an object's location, and that a detected object is "follow[ed] over time." [EX1034, 6:33-53, 6:59-8:33, Figs. 1, 4.] Therefore, it teaches that the location of the object is predicted *incrementally* as claimed. [*Id.*] Moreover, the '711 Patent explains that medium robustness, medium cost algorithms use a "last known location of the object location estimation" and low robustness, low cost algorithms use a "known location of the object location estimation." ['711 Patent, 27:57-64.] Ning's LSTM neural network aligns with both explanations and thus has a medium robustness, medium cost or low robustness, low cost because it uses previous known location predictions

(e.g., “the output of itself [the LSTM] from the last time step t-1, i.e., the location prediction”), uses memory cells “to store and output information, allowing it to better discover long-range temporal relations,” and “learns from experience” to perform its object location prediction. [EX1034, 4:55-5:3, 8:49-52, 10:50-54.]

212. The YOLO neural network of the combination has a “high robustness” and “high cost” (*the first robustness and the first compute cost being greater, respectively,*) and the LSTM neural network has a “medium robustness” and “medium cost” or “low robustness” and “low cost” (*than the second robustness and the second compute cost*). [*Supra* Section XIX.F.2; ’711 Patent, 27:54-64, 28:40-47.] Therefore, the combination renders obvious element [36.d].

G. GROUND 28: SUBSTITUTE CLAIM 37

1. Motivation to Combine

213. A POSITA would have been motivated to combine Beard, Laufer, Pierce, Park, and Redmon (the “BLPPR combination”) for the same reasons discussed above with respect to Beard, Laufer, and Pierce. [*Supra* Section XIX.D.1.] Moreover, a POSITA would have been motivated to combine Beard, Laufer, and Pierce with (1) Park’s teachings of using a “little” and “big” system architecture that determines whether to use a low energy or high energy object detection model based on detection accuracy of the low energy model using a score margin and (2) Redmon’s teachings of using a base YOLO neural network as a high energy

detection model and a fast YOLO neural network as a low energy detection model. [EX1035, 124-131; EX1036, Abstract, 779-783, 786; *See Supra*, Section XIX.F.2 at elements [36.b1], [36.b2], [36.c]; Section XIX.D.1; Pet. 35-36.]

214. Park and Redmon's teachings provide implementation details for how the Beard-Laufer-Pierce system performs object detection. [*Id.*] A POSITA would have recognized Park and Redmon's applicability to object detection and tracking systems implemented by a drone because their teachings provide "energy efficiency and accuracy," which is "critical" to "mobile devices," as well as "fast, accurate" object detection that is "ideal for computer vision applications" and "ideal for applications that rely on fast, robust object detection." [EX1035, Abstract, 124-126; EX1036, 785-786]. A POSITA would have thus readily utilized the teachings of Park and Redmon with the Beard-Laufer-Pierce drone system, and the combination would have had the predictable result of Beard's image processor 234 on board its UAV (i) determining a score margin value associated with using a fast YOLO neural network and (ii) using a base YOLO neural network to detect an object or a fast YOLO neural network to detect an object based on a comparison of the score margin to a threshold. [EX1035, 124-131; EX1036, Abstract, 779-784, 786; *See Supra*, Section XIX.F.2 at elements [36.b1], [36.b2], [36.c]; Section XIX.G.1; Pet. 35-36.] There would have been a reasonable expectation of success in making this combination because the implementation details provided by Park and Redmon are

methods that were well known in the art. [*Id.*] They use straightforward techniques that would have been routine for a POSITA to implement. [*Id.*]

2. Claim 37

a) *Elements [37.pre], [37.a], [37.b], [37.c], [37.d]*

215. **Element [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:”

216. **Element [37.a]:** “receiving an image captured by an image sensor of the reference aerial vehicle;”

217. **Element [37.b]:** “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;”

218. **Element [37.c]:** “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”

219. **Element [37.d]:** “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[.].”

220. The BLPPR combination teaches Beard’s on board UAV image processor 234 detects a target 118 in image frames by applying a machine learning/neural network algorithm and an attitude control system 232 aboard the UAV performs flight control operations such as controlling the speed of one or more UAV rotors (*computer program product...housed in a reference aerial vehicle and comprising computer instructions for: receiving an image...detecting a target in the image...determining a three-dimensional relative location...performing the flight control operation*). [See *Supra*, Section XIX.F.2 at elements [36.b1], [36.b2], [36.c]; Section XIX.G.1; Pet. 35-36.]

b) Elements [37.e1], [37.e2], [37.e3]

221. **Element [37.e1]:** “wherein the detecting of the target comprises: determining a confidence level for the detection of the target, and”

222. **Element [37.e2]:** “using a first neural network having a first robustness and a first refresh rate, or a second neural network having a second robustness and a second refresh rate, the first robustness being greater than the second robustness and the first refresh rate being smaller than the second refresh rate, and”

223. **Element [37.e3]:** “wherein the first neural network is used when the confidence level is below a given threshold and the second neural network is used when the confidence level is above the given threshold.”

224. The BLPPR combination teaches determining a score margin value associated with using a fast YOLO neural network, where the score margin reflects a likelihood that the fast YOLO neural network accurately detected an object. [EX1035, 124-131; EX1036, Abstract, 779-783, 786; *See Supra*, Section XIX.F.2 at elements [36.b1], [36.b2], [36.c]; Section XIX.G.1; Pet. 35-36.] The score margin is, therefore, a confidence level for the target detection (*“wherein the detecting of the target comprises: determining a confidence level for the detection of the target”*). [EX1035, 124-131; EX1036, Abstract, 779-783, 786; *See Supra*, Section XIX.F.2 at elements [36.b1], [36.b2], [36.c]; Section XIX.G.1; Pet. 35-36.]

225. The BLPPR combination teaches using a base YOLO neural network having 24 convolutional layers and a 45 frames per second rate to detect an object (*and using a first neural network having a first robustness and a first refresh rate*) or using a fast YOLO neural network having 9 convolutional layers, fewer filters in those layers, and a 155 frames per second rate to detect an object (*or a second neural network having a second robustness and a second refresh rate*). [EX1035, 124-128; EX1036, Abstract, 779-784, 786.] The fast YOLO is a “smaller version” of the base YOLO. [EX1036, Abstract.] The 24 convolutional layers of the base YOLO neural

network is greater than the 9 convolutional layers of the fast YOLO neural network (*the first robustness being greater than the second robustness*) and the 45 frames per second rate to detect an object of the base YOLO is smaller than the 155 frames per second rate to detect an object of the fast YOLO (*and the first refresh rate being smaller than the second refresh rate*). [EX1035, 124-128; EX1036, Abstract, 779-784, 786.] The BLPPR combination teaches that if the score margin is below a threshold then the base YOLO is used (*and wherein the first neural network is used when the confidence level is below a given threshold*). [Id.] However, if the score margin is above the threshold, then the fast YOLO is used (*and the second neural network is used when the confidence level is above the given threshold*). [Id.]

H. GROUND 29: SUBSTITUTE CLAIMS 21, 23-26, 32

1. Motivation to Combine

226. A POSITA would have been motivated to combine Pierce, Kumar, Khan, and Beard (the “PKKB combination”) for the same reasons discussed in the Petition with respect to Pierce and Kumar (Pet. at 50-53), Pierce and Khan/Pierce, Kumar, and Khan (Pet. at 72-73). Moreover, a POSITA would have been motivated to combine Pierce, Kumar, and Khan with Beard’s teachings of a drone having an on-board control system that controls movement of the drone to track an object. [EX1009, 4:60-63, 5:54-59, Fig. 5.] Beard’s teachings provide explicit implementation details (i.e., use of a controller on-board the UAV) for how a drone

implements flight control. [*Id.*; Pet. at 50-60, 72-73.] This teaching furthers Pierce, Kumar, and Khan’s combined teachings related to such concepts. [*Id.*; Pet. at 50-60, 72-73.] Utilizing Beard’s teachings would have been applying a known technique (drone having an on-board control system that controls movement of the drone) to improve similar devices (drones that control their movement) in the same way. [*Id.*] The combination would have had the predictable result of Pierce’s UAV implementing on-board flight control that controls drone rotor speed and moves the drone to track an object. [*Id.*] Moreover, for the same reasons noted above that the combination reflects mere implementation details, and the overlap in subject matter between the references and compatibility of the references, a POSITA would have had a reasonable expectation of success in making the combination. [*Id.*]

2. Claim 21

a) Element [21.a]

227. **Element [21.a]:** “receiving at a processor at the reference aerial vehicle an image captured by an image sensor of the reference aerial vehicle.”

228. The PKKB combination teaches a “drone system 600 [that] may be drone 102,” and system 600 includes an “object tracking module 615.” [EX1005, ¶¶0027, 0042, 0044-0046, Figs. 1, 6.] A POSITA would have understood or at least found obvious that this module would have been implemented on or as a processor, on drone 102. [EX1005, ¶¶0017, 0027, 0042, 0044-0046, Figs. 1, 6; EX1006,

¶0015.] Object tracking module 615 of the drone 102 receives images of a surrounding area of the drone captured by camera 104 and analyzes them using “various neural networks” (*receiving at a processor at the reference aerial vehicle an image...*). [*Id.*; Pet. at 50-54.]

b) Element [21.b]

229. **Element [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.”

230. *See supra* Ground 23, Element [21.b], for teachings of Kumar and Khan regarding bounding box and classification. In view of such teachings, the PKKB combination teaches Pierce’s on-board object tracking module 615 of drone 102 detects an object (e.g., vehicle) in an image using a neural network applied to the image, which produces a bounding box around the detected object (*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*). [Petition at 50-55; EX1005, ¶¶0017, 0027, 0042, 0044-0046, Figs. 1, 6; EX1006, ¶0015.] In the combination, by performing the detecting of a object (*detecting at the reference aerial vehicle...*), the identified bounding boxes would have outlined detected “shape and appearance” features of

the object as taught by Khan (*to identify a bounding box outlining a portion of the image that includes detected features of the target*). [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7.] Moreover, by performing the detecting of a target (*detecting at the reference aerial vehicle*...), these features would have been used to classify an object as a particular type of object (e.g., vehicle) as taught by Khan (*and to identify a classification of the detected target*). [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7.]

231. Under an alternative interpretation, Pierce’s on board object tracking module 615 of drone 102 applies neural networks to images (*applying at the reference aerial vehicle a machine learning model*...) to generate the bounding box. [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7; EX1005, ¶¶0017, 0027, 0042, 0044-0046, Figs. 1, 6; EX1006, ¶0015; Pet. at 50-55.] The bounding box would have outlined detected “shape and appearance” features of the object as taught by Khan and Kumar (*to identify a bounding box outlining a portion of the image that includes detected features of the target*). [Id.; EX1021, ¶¶0045-0063, Figs. 6, 7; EX1005, ¶¶0017, 0027, 0042, 0044-0046, Figs. 1, 6; EX1006, ¶0015; Pet. at 50-55.] Moreover, Pierce’s on board object tracking module 615 applies neural networks (*applying at the reference aerial vehicle a machine learning model*...) that would have classified the object as a particular type of object based on the features as taught by Khan (*and to identify a classification of the detected target*). [Id.]

c) Element [21.c]

232. **Element [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.”

233. The PKKB combination teaches Pierce’s on board object tracking module 615 of drone 102 determines relative position (x_0, x_1, x_2) of the object with respect to the drone (*determining at the reference aerial vehicle a three-dimensional relative location of the target...*). [Pet. at 50-56; EX1005, ¶¶0017, 0027, 0042, 0044-0046, Figs. 1, 6; EX1006, ¶0015.] This determination of relative location uses the “straight-line distance” value d ; this value d is determined using (1) a value A that represents the “area of the bounding box in pixels,” specifying the area of a bounding box of a target object that is detected and tracked in the processed image, and (2) a value s that represents the “physical length of the diagonal across the box for an average instance of the object” (*determining...a three-dimensional relative location of the target...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*). [Pet. at 50-56.]

234. Moreover, Khan teaches classification of a target into a particular type (e.g., an SUV, sedan, etc.) as discussed above for Element [21.b]. [EX1021, ¶¶0003, 0037-0039, 0044-0063, Figs. 7-8; EX1007, ¶¶0020, 0035, Fig. 2; EX1008, ¶¶0018, 0030, Fig. 2.] Kumar teaches a target tracking system that recognizes a target in captured images and produces a bounding box around the target. [EX1021, ¶¶0003, 0037-0039, 0044-0063, Figs. 7-8; EX1007, ¶¶0020, 0035, Fig. 2; EX1008, ¶¶0018, 0030, Fig. 2.] Kumar's system 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." [EX1007, ¶¶0019-0025, 0037, Fig. 3A; EX1008, ¶¶0018-0023, 0032, claims 4-5, claims 14-15; claims 24-25, Fig. 3A; EX1003, ¶¶157-158.] Thus, Khan teaches classifying a target in an image as a particular type, and Kumar teaches determining a relative position using a physical size of such a type of target. [EX1007, ¶¶0019-0025, 0037, Fig. 3A; EX1008, ¶¶0018-0023, 0032, claims 4-5, claims 14-15; claims 24-25, Fig. 3A; Petition at 50-56, 72-73; EX1003, ¶¶162-163.] Therefore, the PKK combination teaches that the distance between Pierce's drone 102 and target object would further have been based on a physical size (as taught by Kumar) corresponding to the classified type of target object identified in a captured image (as taught by Khan) *(determining a distance to the target based at least in part on...and on a physical*

size corresponding to the classification of the target detected within the image).

[EX1007, ¶¶0019-0025, 0037, Fig. 3A; EX1008, ¶¶0018-0023, 0032, claims 4-5, claims 14-15; claims 24-25, Fig. 3A; Petition at 50-56, 72-73; EX1003, ¶¶162-163.]

d) Element [21.d]

235. **Element [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 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.”

236. Pierce describes controlling movement of its drone, and a POSITA would have understood or at least found obvious that this occurs using the processor 601 on board drone 102 and/or a drone controller on board drone 102 (*performing at the reference aerial vehicle the flight control operation...*). [Pet. at 50-53, 56-60; EX1005, ¶¶0017, 0019, 0025-0027, 0042, 0044-0046, Figs. 1, 6.] Additionally, Beard teaches using an “attitude control system” that is on-board a drone that controls the speed of one or more drone rotors, “thereby adjusting the speed, direction, or rotational orientation” and “pitch, yaw, or roll angle” of the drone. [EX1009, 4:60-63, 5:54-59, Fig. 5.] In view of this teaching, the PKKB combination thus teaches that a control system on-board Pierce’s drone 102 implements flight

control operations that move the drone to track a moving object (*performing at the reference aerial vehicle the flight control operation...*). [*Id.*; Pet. at 50-53, 56-60; EX1005, ¶¶0017, 0019, 0025-0027, 0042, 0044-0046, Figs. 1, 6.]

3. **Claim 24**

237. Claim 24 recites: “The method of claim 21, wherein detecting the target in the image including by applying at the reference aerial vehicle the machine leaning model to the image includes identifying a model type of the target based on the classification of the detected target.”

238. Khan teaches classification of an object in an image into a type such as an SUV, sedan, van, etc. [EX1021, ¶¶0003, 0037-0039, 0044-0063, Figs. 7-8.] The PKKB combination thus teaches that the target detection by Pierce’s object tracker 615 on-board drone 102 applying neural networks to image frames includes identifying a model type (e.g., a vehicle model type such as an SUV, sedan, van, etc) based on the classification of the target object as a particular model type (*wherein detecting the target in the image including by applying at the reference aerial vehicle the machine leaning model to the image includes identifying a model type of the target based on the classification of the detected target*). [*Supra* Section XIX.H.1-2; Pet. at 72-73.]

4. **Claims 23, 25, 26, and 32**

239. Claims 23, 25, 26, and 32 are obvious for the same reasons discussed in the Petition regarding claims 3, 8, 9, and 15, respectively. [Pet. at 50-53, 60, 62-66.] The same reasoning there applies to the PKKB combination.

I. GROUND 30 AND 31

240. Claims 22, 29, and 35 depend from claim 21. Pierce, Khan, Kumar, Beard, and Laufer is Ground 30 and renders obvious Substitute Claims 22, 29, and 35 for the same reasons discussed above for claim 21, as well as the same reasons discussed in the Petition regarding claims 2, 12, and 18, respectively. [Pet. at 68-75.]

241. Substitute Claim 34 depends from Substitute Claim 21. Pierce, Khan, Kumar, Beard, and Hogasten is Ground 31 and renders obvious Substitute Claim 34 for the same reasons discussed above regarding Independent Substitute Claim 21, as well as the same reasons discussed in the Petition regarding claim 17. [Pet. at 68-75.]

242. Moreover, a POSITA would have been motivated to combine Laufer with Pierce, Khan, Kumar, and Beard, as well as Hogasten with Pierce, Khan, Kumar, and Beard, for at least the same reasons discussed in the Petition, as well as the same reasons discussed above in Section XIX.H.1 and Pet. at 68-75.

J. GROUND 32 SUBSTITUTE CLAIM 36

1. Motivation to Combine

243. A POSITA would have been motivated to combine Pierce, Kumar, Ning, and Beard for the same reasons discussed in Section XIX.F.1 regarding Ning

and Section XIX.H.1 regarding Beard. The combination would have resulted in the predictable result of Pierce's drone 102 performing on-board flight control and on-board object tracking module 615 of drone 102 detecting an object (e.g., vehicle) in an image by applying a YOLO neural network and determining a relative location (x_0, x_1, x_2) of an object by using a LSTM neural network to predict and track the location of a target in an analyzed image. [*Supra* Sections XIX.F.1, XIX.H.1; Pet. 50-60, 66-68.] The combination would have had a reasonable expectation of success because YOLO and LSTM were known object detection and tracking techniques well suited to use in vehicle applications due to their speed and ability to provide real-time results. [EX1034, Abstract, 1:51-2:3, 2:15-19, 2:35-62, 3:3-17, 4:38-5:3, 5:46-54, 6:15-53, 6:59-8:33, 8:41-9:4, 9:30-37, 9:61-10:32, 10:55-11:13, 12:55-13:2, Figs. 2, 4, 5, 6, 8; EX1036, 779, 785-786.]

2. **Claim 36**

a) Elements [36.b1], [36.b2], [36.c]

244. **Element [36.b1]:** “a processor configured to: detect a target in the image; and”

245. **Element [36.b2]:** “determine a three-dimensional relative location of the target with respect to the reference aerial vehicle based on the image; and”

246. **Element [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.”

247. Pierce’s on-board object tracking module 615 of a drone detects an object in image frames by applying neural networks to image frames and determines a relative location between the UAV and an object. Flight control is performed on board the drone as taught by Beard. [Sections XIX.F.2 (Elements [36.b1], [36.b2], [36.c]), XIX.H.1-2; Pet. at 66-67.] This teaches elements [36.b1], [36.b2], and [36.c].

b) Element [36.d]

248. **Element [36.d]:** “ “[36.d] wherein the detecting of the target in the image is performed using 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 using 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.”

249. Pierce's drone 102 performs on-board flight control, and on-board object tracking module 615 of drone 102 detects an object (e.g., vehicle) in an image by applying a YOLO neural network and determines a relative location (x_0, x_1, x_2) of an object by using a LSTM neural network to predict and track the location of a target in an analyzed image. [*Supra* Sections XIX.F.1, XIX.H.1; Pet. 50-60, 66-68.] The combination teaches element [36.d] for the same reasons discussed with respect to Ning in Section XIX.F.2.

K. GROUND 33: SUBSTITUTE CLAIM 37

1. Motivation to Combine

250. A POSITA would have been motivated to combine Pierce, Kumar, Park, Redmon, and Beard for the same reasons discussed in Section XIX.G.1 regarding Park and Redmon and Section XIX.H.1 regarding Beard. The combination would have resulted in the predictable result of Pierce's object tracking module 615 on board its drone determining a score margin value associated with using a fast YOLO neural network and using a base YOLO neural network to detect an object or a fast YOLO neural network to detect an object based on a comparison of the score margin to a threshold. [*Supra* Sections XIX.G.1, XIX.H.1; Pet. 50-60, 66-68.] There would have been a reasonable expectation of success in making this combination because the implementation details provided by Park and Redmon are

methods that were well known in the art. [*Id.*] They use straightforward techniques and would have been routine for a POSITA to implement. [*Id.*]

2. Claim 37

a) *Elements [37.pre], [37.a], [37.b], [37.c], [37.d]*

251. **Element [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:”

252. **Element [37.a]:** “receiving an image captured by an image sensor of the reference aerial vehicle;”

253. **Element [37.b]:** “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;”

254. **Element [37.c]:** “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”

255. **Element [37.d]:** “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[.].”

256. Pierce’s on-board object tracking module 615 of a drone detects an object in image frames by applying neural networks to image frames and determines a relative location between the UAV and an object. Flight control is performed on board the drone as taught by Beard. [Sections XIX.J.2 (Elements [36.b1], [36.b2], [36.c]), XIX.H.1-2; Pet. at 66-67.]

b) Elements [37.e1], [37.e2], [37.e3]

257. **Element [37.e1]:** “wherein the detecting of the target comprises: determining a confidence level for the detection of the target, and”

258. **Element [37.e2]:** “using a first neural network having a first robustness and a first refresh rate, or a second neural network having a second robustness and a second refresh rate, the first robustness being greater than the second robustness and the first refresh rate being smaller than the second refresh rate, and”

259. **Element [37.e3]:** “wherein the first neural network is used when the confidence level is below a given threshold and the second neural network is used when the confidence level is above the given threshold.”

260. Pierce’s drone 102 performs on board flight control, and Pierce’s object tracking module 615 on board its drone determines a score margin value associated

with using a fast YOLO neural network. [*Supra* Sections XIX.G.1, XIX.H.1; Pet. 50-60, 66-68.] Module 615 uses a base YOLO neural network to detect an object or a fast YOLO neural network to detect an object based on a comparison of the score margin to a threshold. [*Supra* Sections XIX.G.1, XIX.H.1; Pet. 50-60, 66-68.] The combination teaches **elements [37.e1], [37.e2], and [37.e3]** for the same reasons discussed with respect to Park and Redmon in Section XIX.G.2.

L. GROUND 34-38

261. Pierce, Khan, Kumar, Beard, and Sahasrabudhe (Ground 34) render obvious claims 21, 23-26, and 32 for the same reasons as discussed for Ground 29 above and in the Petition regarding claims 1, 3, 8, 9, 15, and further render obvious claims 31 and 33 for the same reasons discussed in the Petition regarding claims 14 and 16. [Pet. at 75-80.]

262. Pierce, Khan, Kumar, Beard, Sahasrabudhe, and Laufer (Ground 35) render obvious claims 22, 29, and 36 for the same reasons as discussed for Ground 30 above and in the Petition regarding claims 2, 12, and 18. [*Id.* at 80.]

263. Pierce, Khan, Kumar, Beard, Sahasrabudhe, and Hogasten (Ground 36) render obvious claim 34 for the same reasons as discussed for Ground 31 above and in the Petition regarding claim 17. [*Id.*]

264. Pierce, Kumar, Sahasrabudhe, and Ning (Ground 37) render obvious claim 36 for the same reasons discussed for Ground 32 above. [*Id.*]

265. Pierce, Kumar, Sahasrabudhe, Park, and Redmon (Ground 38) render obvious claim 37 for the same reasons discussed for Ground 33 above. [*Id.*]

266. A POSITA would have been motivated to combine the references of each of Grounds 34-38 for the reasons discussed in the Petition at pages 75-80, as well as the reasons discussed above for Grounds 29-33, respectively.

XX. CONCLUSION

267. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. I further understand that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code. I declare under penalty of perjury that the foregoing is true and correct.

Executed on March 9, 2026.



Dr. William Singhose

APPENDIX

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