

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

HESAI TECHNOLOGY CO., LTD.
Petitioner

v.

OUSTER, INC.
Patent Owner

Case IPR 2023-01421
U.S. Patent No. 11,175,405
Issue Date: November 16, 2021

Title: SPINNING LIDAR UNIT WITH MICRO-OPTICS ALIGNED BEHIND
STATIONARY WINDOW

CORRECTED¹ DECLARATION OF JASON A. JANÉT, PH.D.

¹ This declaration is identical to the Declaration of Jason A. Janét, Ph.D. filed on June 25, 2024 as EX2010 but for the fact that it has been corrected to include an oath from Dr. Janét (p. 96) that was inadvertently not included in the June 25, 2024 declaration.

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EXHIBIT LIST

EXH. NO.	DESCRIPTION
2001	Respondent's Proposed Claim Construction dated June 28, 2023, filed in ITC Inv. No. 337-TA-1363
2002	Respondent's Proposed List of <i>Markman</i> Exhibits dated July 13, 2023, filed in ITC Inv. No. 337-TA-1363
2003	Excerpts from <i>Fluorescence Microscopy, Principles to Biological Apps</i> (2d ed. 2017)
2004	Excerpts from Merriam-Webster's Collegiate Dictionary (11th ed. 2014)
2005	Respondent's Proposed List of Terms to be Construed dated June 21, 2023, filed in ITC Inv. No. 337-TA-1363
2006	Excerpts from Rudolf F. Graf, <i>Modern Dictionary of Electronics</i> (7th ed. 1999)
2007	Excerpts from Frank Pedrotti, <i>Introduction to Optics</i> (3d ed. 2006)
2008	Biography of Patrick W. Lauppe
2009	Declaration of Patrick W. Lauppe ISO Motion for <i>Pro Hac Vice</i> Admission
2010	Declaration of Jason A. Janét, Ph.D.
2011	Transcript of James F. Shanley, Ph.D., deposition dated June 6, 2024
2012	U.S. Patent No. 7,969,558, to David S. Hall
2013	Warren J. Smith, <i>Practical Optical System Layout and Use of Stock Lenses</i> (1997)
2014	Sergey L. Vinogradov, "Evaluation of performance of silicon photomultipliers in LIDAR applications" (2017)

EXH. NO.	DESCRIPTION
2015	Edoardo Charbon et al, “SPAD-Based Sensors” (2013)
2016	Cristiano Niclass, et al, “A Single Photon Avalanche Diode Array Fabricated in Deep-Submicron CMOS Technology” (2006)

I. BACKGROUND AND QUALIFICATIONS

1. My name is Jason Janét. I have prepared this declaration as an expert witness on behalf of Ouster, Inc (“Ouster”). I have been retained by Ouster at my standard rate of \$475. In this declaration, I provide my opinion as to whether claims 21 and 23-34 of U.S. Patent No. 11,175,405 (the “’405 patent”) (**EX1001**) are valid in light of certain alleged prior art references. I also provide herein the technical bases for these opinions, as appropriate.

2. My credentials are set forth in full detail in my Curriculum Vitae which is attached as Exhibit A, incorporated here by reference, and summarized as follows: I am currently CTO for Applied Research Associates (ARA). I also hold the rank of Adjunct Associate Professor at Duke University and at North Carolina State University.

3. I received a Bachelor of Science in Mechanical Engineering from the University of Virginia in 1990; a Master of Integrated Manufacturing Systems from the Integrated Manufacturing Systems Engineering Institute at North Carolina State University in 1994; and a Ph.D. in Electrical and Computer Engineering from North Carolina State University in 1998.

4. Since 1991, I have been active in the robotics, sensors, artificial intelligence, pattern analysis, and automation fields. My MS thesis, entitled *Global Motion Planning and Self-Referencing for Autonomous Mobile Robots*, leveraged

graph theory and time-of-flight and/or Doppler sensors to optimize mobile robot movement through, and perception of, environments. My PhD dissertation, entitled *Pattern Analysis, Tracking and Control for Autonomous Vehicles*, leveraged multiple UGVs, time-of-flight and/or Doppler sensors, point clouds, and neural networks to enhance simultaneous localization and mapping (SLAM), as well as the sharing of knowledge between multiple different UGVs. I have authored numerous publications and have co-authored a textbook entitled *Computational Intelligence*.

5. I have designed, built, and marketed toys, robots, automated systems, measuring systems and components thereof, including ground mobile robots, unmanned aerial vehicles (UAV), unattended sensors, automated storage and retrieval systems (ASRS), submersible mobile robots, proof-of-concept extra-terrestrial robots, manually-manipulated (“twiddled”) submersible foils, wall climbing mobile robots, corner-grip ballgame goals, proximity and ranging systems, point-cloud systems, pattern analysis tools, and augmented reality systems.

6. I have taught the following courses: Introduction to Robotics and Automation (Duke and NCSU); Introduction to Control Theory (Duke and NCSU); Distributed Real-Time Controls (NCSU); and myriad independent studies courses in the areas of robotics, automation, artificial intelligence, autonomy, pattern analysis, sensors, and control systems. I have also served on several MS- and PhD-level graduate student committees, designed qualifying exam problems, served on

the NCSU IMSEI Board, and participated in curriculum development for undergraduate and graduate level programs.

7. I have also started, sponsored, and advised multiple champion student teams for international robot competitions including, but not limited to, the NASA/ASCE Extra-Terrestrial Robotics Competition, the DARPA Grand Challenge, the AUVSI/ONR Autonomous Underwater Vehicle Competition, and the European CLAWAR Wall-Climbing Robot competition.

8. I have initiated multiple unmanned systems projects at both academic and industry levels. Academic unmanned aerial vehicles (UAVs) include, but are not limited to, Quadcopters with Hybrid Remote and Autonomous Control, Marsupial UAVs that Deploy and Recover Unmanned Ground Vehicles, and Wall-Climbing UAVs. Additionally, the AngelFish Cross-Domain Submersible UAV, a DARPA ASW program that I incubated and procured funding for at Teledyne, included a partnership with North Carolina State University. Unmanned underwater vehicles (UUVs) include, but are not limited to, the MicroHunter-class of very small underwater robots, the PilotFish, Gamera, Artemis and other holonomic robots, and submersible crawlers that are used in nuclear boiler water reactors, the LBC hull inspection system, and the HULLBUG hull cleaning system. Unmanned ground vehicles (UGVs) include, but are not limited to, the miniature PERRY, wall-climbers, all-terrain and subterranean crawlers.

9. I have also supported multiple toy-focused ventures with companies including, but not limited to, Marvel, Hasbro, Twidco, Spin Master, Nottingham-Spirk, IDEO, ARA, and other firms. For Marvel, multiple Spiderman toys were conceived and developed and validated, including the Spiderman Wall-Climbing Car, the Corner-Climbing Spider, and the Inflatable Wall-Climbing Spiderman. For Hasbro, a proprietary corner-gripping technology was employed to place basketball goals in corners. For Twidco, a proprietary flapping foil technology was combined with multiple fish shapes (e.g., shark and clownfish) to enable users to create fish-like motion by “twiddling” a connecting cable from above. For Spin Master and multiple design firms, multiple wall-climbing toys were developed for small wall-climbing robot concepts including simple radio control vehicles and the “Hangtime 540” Tony Hawk aerial skateboard toy. For ARA, augmented reality systems for indoor and outdoor games.

10. In 1999, while I was employed by Nekton Research (“Nekton”), I captured and managed multiple programs sponsored by the Department of Defense (DoD) and private-sector companies that focused primarily on autonomous underwater vehicles (AUV), remotely operated vehicles (ROV), TwiddleFish toys, and indirect-fire projectiles. During my tenure, Nekton entered into a joint venture agreement with the founders of what eventually became known as Parata Systems – a pharmacy automation solutions company, which I supported launching.

11. After leaving Nekton in March 2002, I joined a then New Jersey-based company called Avionic Instruments, Inc (“Avionic”). While at Avionic, I continued developing and marketing robots and supported engineering related to various design, manufacturing, quality and assembly issues on the core aerospace product lines. Avionic product lines include, but are not limited to, ducted fans, transformer-rectifier units (TRU), regulated TRU (RTRU), auxiliary power unit (APU) control systems, power distribution systems (PDU), frequency converters, corner clamps, and VRAM attractors/thrusters. Customers included DoD, NASA, Boeing, Sikorsky, Augusta-Westland, Dassault, and Lockheed-Martin.

12. At Avionic, I was also tasked with ruggedizing, optimizing, and commercializing two emerging proprietary technologies: the “CFG” and “VRAM”. The CFG, short for Corner Friction Grip, was a proprietary technology based on non-marring and non-adhesive materials that provided optimal grip patterns on inside and outside corners. CFG formed the basis of a company called “Shelf Works Technologies,” which was spun out of Avionic instruments in 2004, and whose products were sold in Home Depot, Bed Bath and Beyond, etc. CFG also formed the basis of multiple toys including a miniature basketball goal for Hasbro, and a corner climbing Spiderman toy for Marvel.

13. The VRAM, short for Vortex Regenerative Air/Aqueous Movement is a patented method for producing attraction forces between an object and a surface.

VRAM is euphemistically referred to as a “tornado in a cup” and generally comprises both cylindrical and toroidal flow patterns that result in vacuum-like regions. The VRAM had several applications, including but not limited to: holding breaching charges and sensors against vertical or inverted surfaces; acting as an attractor for wall and ceiling climbing robots; acting as an attractor for submersible hull-crawling robots; filter-less vacuuming (conceptually similar to the Dyson vacuum); and robotic pick-and-place end-effector (conceptually similar to a gripper) to move articles from one location (e.g., a conveyor) to another (e.g., a collator). The VRAM also formed the basis for multiple toys including: a wall-climbing car for Spin Master, IDEO and Nottingham-Spirk; a Spiderman car for Marvel; an inflatable wall-climbing Spiderman for Marvel; and the Tony Hawk Hangtime 540 aerial skateboard for IDEO.

14. My work with the filter-less vacuum VRAM prompted me to explore a concept related to pharmacy automation, which ultimately led to a Ferris-wheel concept for rapidly dispensing pills. In mid-2003, my team conceived of two prescription pill counting mechanisms that actually benefitted from centrifugal forces and optimally exploited gravity and vacuum: an inner ring with vacuum-based apertures and an inner-bowl with vacuum-based apertures. The inner-bowl with vacuum-based apertures was deemed most viable, was awarded two US patents, and to this day forms the basis of the RxMedic ADST[™] pharmacy robot. The VRAM

formed the basis of Vortex HC technologies, many of which have been licensed out to entities including, but not limited to Teledyne SeaBotix, SeaRobotics, and HDT. Both RxMedic and Vortex HC were officially spun out of Avionic in July 2004, at the date Avionic was acquired by Transdigm.

15. In late 2004, soon after Avionic was acquired, I, along with others from Avionic, secured funding to develop an alpha-level multi-dispenser pharmacy robotic system and develop the RxMedic business plan and raise multiple rounds of venture capital. In late 2006, RxMedic (called “APDS” until November 2006) was launched as a stand-alone, sole-focus venture. After the operational launch of RxMedic, I served as General Manager and eventually Chief Technical Officer. Through my roles at RxMedic, I oversaw the development of the RxMedic ADS robot, managed the intellectual property portfolio, coordinated sales and marketing, and provided strategic, fiscal, and operational leadership. In May 2010, J.M. Smith Corporation acquired RxMedic, and to assist in the change of ownership, I served as a Director of RxMedic until May 2011.

16. Also in late 2004, after Avionic was acquired, I, along with others from Avionic, secured funding for Vortex HC through DoD contracts and robot sales, to continue developing the VRAM Mobile Robot Platform (VMRP – a wall-climbing robot), the ARTEMIS AUV (a holonomic submersible robot for counter-mine and counter-obstacle operations), the submersible crawler, the nuclear-grade boiler

water reactor (BWR) inspection robot, and other robot products centered around the VRAM. Some DoD programs were/are classified, for which I maintained a SECRET clearance at both the personal and facilities level, and served as the facilities security officer (FSO). In late 2006, corresponding to the full launch of RxMedic, Vortex HC technologies were largely licensed to Teledyne SeaBotix, SeaRobotics, and HDT. However, I have continued to support Vortex HC licensees and customers to-date.

17. After the sale of RxMedic, and after fulfilling my 12-month employment obligation, I joined Teledyne Technologies in Summer 2011. I served as the Senior Manager for the RTP division of Teledyne Scientific, and supported multiple DoD-sponsored robotic-focused programs. Some of these programs were/are classified, for which I maintained a personal SECRET clearance. Among these programs, were cargo unmanned ground vehicles (CUGV); squad-level autonomous unmanned ground vehicles (UGV); autonomous underwater vehicles (AUV); unmanned underwater vehicles (UUV); a cross-domain autonomous vehicle capable of transitioning between air-, surface- and underwater-domains; the EXACTO program for optically tracking and steering bullets to targets; and LIDAR systems for UGVs, as well as the mapping of urban and subterranean environments (along with sister-company Optech). Cross-domain vehicles that were evaluated, designed and prototyped included, but were not limited to, the AngelFish (later

called “EagleRay”) cross-domain submersible UAV for anti-submarine warfare, as well as a ball-shaped robot for beach-, ground- and surf-zone countermine operations. Sensor design, refinement and signal processing was a major component of each program. Sensors employed include, but are not limited to: proximity sensors; ranging sensors; electro-optical imaging; LIDAR. long-, short- and mid-wave infrared (IR); inertial measurement units (IMU); optical flow; and radio-frequency (RF). Additionally, control systems were designed, refined and integrated into the aforementioned systems. Most control systems were closed-loop, in that they utilized sensor-based feedback; others were open-loop, where states were estimated with little or no feedback.

18. In late 2013, Avionic, a Transdigm business unit at that point, requested that I return to turn around both a supply-chain issue, and the Sikorsky S97 Raider/JMR helicopter programs. The S97 Raider was designed to be the fastest, most maneuverable helicopter, due to its coaxial, counter-rotating variable-pitch wings, and an aft-based push-propeller. Avionic also controlled two business units named Acme Aerospace (Acme) and Aerospace Cooling Solutions (ACS). Avionic, Acme and ACS supported the S97 program, which ultimately met milestones and continues to produce multiple successful demonstrations. In 2013, Transdigm expanded my role to include directorship of the Avionic, Acme and ACS revenue and engineering teams, and to report operational and financial status at six-week

intervals. Transdigm required that I move my family to New Jersey in late 2014, which influenced my decision to resign and assume the CEO role offered to me by Delta Five Systems in Raleigh, NC.

19. As CEO of Delta Five, I led a private-equity backed, hospitality-focused venture, coordinating the company's launch and strategic path including an early-stage pivot. Initially focused on back-end robotics and automation, Delta Five shifted its focus to address the rampant bed bug problem—a top priority for hoteliers—with a novel unattended sensor and trap, called the Telemetered Pest Monitoring System (TPMS), which is based on computer vision and internet of things (IoT), and has proven capable of scaling to other pests. In addition to the TPMS, Delta Five developed a novel means to mass produce a natural, unscented aggregation pheromone that, in concert with placement and heat, lured invertebrates to the TPMS. After leading Delta Five and serving on its Board for four years, I resigned to join ARA, but continue serving Delta Five as a share-holder and transition agent.

20. In 2018, I joined ARA as CTO. My primary responsibilities include leading the commercialization and technology transition efforts, which require technical, business and corporate development, as well as the procurement of capital and managing matrixed rosters.

21. I have served as an expert witness on multiple cases including cases

involving IPR, ITC, contract disputes, and civil litigation in District and Federal Courts. My resume lists these cases.

22. In formulating my opinions, I have relied upon my training, knowledge, and experience in the relevant art.

II. LEGAL STANDARDS

23. In formulating my opinions and conclusions in this proceeding, I have been provided with an understanding of the prevailing principles of U.S. patent law that govern the issues of patent validity.

A. Claim Construction

24. I understand that the purpose of claim construction is to determine what a person of ordinary skill in the art would have understood the claim terms to mean. Claim terms are generally given their ordinary and customary meaning, which is the meaning that the term would have to a person of ordinary skill in the art in question as of the effective filing date.

25. I understand that the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification. I understand that the patent specification, under the legal principles, has been described as the single best guide to the meaning of a claim term, and is thus highly relevant to the interpretation of claim terms. And I understand for terms that do not

have a customary meaning within the art, the specification usually supplies the best context of understanding the meaning of those terms.

26. I further understand that other claims of the patent in question, both asserted and unasserted, can be valuable sources of information as to the meaning of a claim term. Because the claim terms are normally used consistently throughout the patent, the usage of a term in one claim can often illuminate the meaning of the same term in other claims. Differences among claims can also be a useful guide in understanding the meaning of particular claim terms.

27. I understand that the prosecution history can further inform the meaning of the claim language by demonstrating how the inventors understood the invention and whether the inventors limited the invention in the course of prosecution, making the claim scope narrower than it otherwise would be. Extrinsic evidence, such as dictionaries, may also be consulted in construing the claim terms.

28. I understand that, in *Inter Partes* Review (IPR) proceedings, a claim of a patent shall be construed using the same claim construction standard that would be used to construe the claim in a civil action filed in a U.S. district court (which I understand is called the “*Phillips*” claim construction standard), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.

29. I have been instructed by counsel to apply the “*Phillips*” claim construction standard for purposes of interpreting the claims in this proceeding, to the extent they require an explicit construction. The description of the legal principles set forth above thus provides my understanding of the “*Phillips*” standard as provided to me by counsel.

30. I understand that certain terms appearing in the challenged claims have been the subject of dispute in an ITC proceeding.

31. I understand that the parties have proposed claim constructions for various terms of the challenged claims in an ITC proceeding. I also understand that no claim construction has taken place in that proceeding.

32. Where claim construction issues arise, I have noted them in my analysis below.

B. Anticipation

33. I am informed and understand that to anticipate a patent claim under 35 U.S.C. § 102, a single asserted prior-art reference must disclose each and every element of the claimed invention, either explicitly or inherently, to a person of ordinary skill in the art. There must be no difference between the claimed invention and the disclosure of the alleged prior-art reference as viewed from the perspective of the person of ordinary skill in the art.

34. Also, I understand that for a reference to be an anticipating reference,

it must describe the claimed subject matter with sufficient clarity to establish that the subject matter existed and that its existence was recognized by persons of ordinary skill in the field of the invention.

35. In addition, I am informed and understand that to establish that an element of a claim is “inherent” in the disclosure of an asserted prior-art reference, the extrinsic evidence (or the evidence outside the four corners of the asserted prior-art reference) must make clear that the missing element is the inevitable outcome of the process and/or thing that is explicitly described in the asserted prior-art reference, and that it would be recognized as necessarily present by persons of ordinary skill in the relevant field.

C. Obviousness

36. I am also informed and understand that even though a prior-art reference does not fully anticipate a claim of a patent, a claim may nonetheless be rendered obvious to a person of ordinary skill in the art if the differences between the subject matter set forth in the patent claim and the prior art are such that the subject matter as a whole of the claim would have been obvious at the time the claimed invention was made.

37. I am informed and understand that obviousness is a determination of law based on various underlying determinations of fact. In particular, these underlying factual determinations include (1) the scope and content of the prior art;

(2) the level of ordinary skill in the art at the time the claimed invention was made; (3) the differences between the claimed invention and the prior art; and (4) the extent of any proffered objective *indicia* of nonobviousness. I understand that the objective *indicia* which may be considered in such an analysis include commercial success of the patented invention (including evidence of industry recognition or awards), whether the invention fills a long-felt but unsolved need in the field, the failure of others to arrive at the invention, industry acquiescence and recognition, initial skepticism of others in the field, whether the inventors proceeded in a direction contrary to the accepted wisdom of those of ordinary skill in the art, and the taking of licenses under the patent by others, among other factors.

38. I am informed and understand that to ascertain the scope and content of the prior art, it is necessary to first examine the field of the inventor's endeavor and the particular problem for which the invention was made. The relevant prior art includes prior art in the field of the invention, and also prior art from other fields that a person of ordinary skill in the art would look to when attempting to solve the problem.

39. I am informed and understand that a determination of obviousness cannot be based on the hindsight combination of components selectively culled from the prior art to fit the parameters of the patented invention. Instead, it is my understanding that to render a patent claim invalid as being obvious from a

combination of references, there must be some evidence within the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination in a way that would produce the patented invention.

40. I am further informed and understand that in an obviousness analysis, neither the motivation nor the purpose of the patentee dictates. What is important is whether there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent's claims.

41. In addition, it is my understanding that to find a patent claim invalid for obviousness, there must be a finding that each element in each limitation of the patent claim is disclosed, taught, or suggested by the asserted combination of prior-art references or elsewhere in the relevant prior art. I understand, however, that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was, independently, known in the prior art. But multiple prior-art references or elements may, in some circumstances, be combined to render a patent claim obvious. I understand that I should consider whether there is an "apparent reason" or motivation to combine the prior-art references or elements in the way the patent claims. To determine whether such an "apparent reason" or motivation exists to combine the prior-art references or elements in the way a patent claims, it will often be necessary to look to the interrelated teaching of multiple prior-art references, to the effects of demands

known to the design community or present in the marketplace, and to the background knowledge possessed by a person of ordinary skill in the art.

42. I also understand that when the prior art “teaches away” from combining prior-art references or certain known elements, discovery of a successful means of combining them is more likely to be nonobvious. A prior-art reference may be said to “teach away” from a patent when a person of ordinary skill in the art, upon reading the reference, would be discouraged from following the path set out in the patent or would be led in a direction divergent from the path that was taken by the patent. Additionally, a prior-art reference may “teach away” from a claimed invention when substituting an element within that prior-art reference for a claim element would render the claimed invention inoperable.

43. I am informed and understand that a patent for a combination which only recites old elements with no change in their respective functions withdraws what is already known into the field of its monopoly and diminishes the resources available to person of ordinary skill in the field. When a patent claims a structure already known in the prior art that is altered by mere substitution of one element for another known in the field, the combination must do more than yield a predictable result. I am informed and understand that the corollary to this principle is that when the prior art teaches away from combining known elements, discovery of a successful means of combining them is more likely to be nonobvious. Thus, the

question to be answered is whether someone reading the prior art would be discouraged from following the path taken by the inventor.

44. I am further informed and understand that when an element is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill in the art can implement a predictable variation of that available element, Section 103 likely renders the invention obvious. For the same reason, I am informed and understand that if a technique has been used to improve one device or process, and a person of ordinary skill in the art would recognize that such technique would improve similar devices or processes in the same way, using the technique is obvious unless its actual application is beyond his or her skill. Following these principles often requires one to look to interrelated teachings of multiple patents; the effects of demands known to the design community present in the marketplace; and the background knowledge possessed by a person having ordinary skill in the art to determine whether there was an apparent reason to combine the known element in the manner claimed by the patent at issue. I am further informed and understand that the analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim, because one can take account of the inferences and creative steps that a person of ordinary skill in the art would employ.

45. I am further informed and understand that although the use of the

“teaching, suggestion or motivation” test for combining references has not been completely rejected, the obviousness analysis cannot be confined by a formalistic conception of the words teaching, suggestion, and motivation, or by overemphasis on the importance of published articles and the explicit content of issued patents. Under the correct analysis, any need or problem known in the field of endeavor at the time of the invention and addressed by the patent can provide a reason for combining the elements in the manner claimed. Finally, I am informed and understand that common sense teaches that familiar items may have obvious uses beyond their primary purposes and, in many cases, a person of ordinary skill in the art will be able to fit the teachings of multiple patents together like pieces of a puzzle.

D. Written Description

46. I understand that one requirement of a patent’s disclosure is that the patent’s specification must meet the “written description” requirement of § 112 paragraph 1.

47. To have an adequate written description, I understand the patent must convey with reasonable clarity to one skilled in the art that, as of the filing date sought, the patentee was in possession of the invention.

48. To demonstrate possession of the invention, I understand the specification must permit a person of ordinary skill in the art to recognize the subject matter purportedly described. Although the specification need not describe the

claimed subject matter verbatim to demonstrate possession of the invention, generalized language will not suffice if it does not convey the detailed identity of an invention.

49. To have an adequate written description, each element of the claimed invention must be actually or inherently disclosed in the specification; it is not sufficient that the specification may render the claim element obvious to a person of ordinary skill in the art.

50. In addition, the patent's specification must contain sufficient written description so that a person of ordinary skill in the art would have had reasonable certainty as to the process and manner of making and using the alleged invention.

E. Enablement

51. In addition to the written description requirement, I understand that a patent's specification must describe the claimed invention in such full, clear, concise, and exact terms as to enable one of ordinary skill in the art to make and use the full scope of the claimed invention without undue experimentation. I also understand that in determining whether a patent meets this requirement, one considers the level of ordinary skill in the art as of the priority date of the patent. I further understand that a claim is invalid if it is not supported by an enabling disclosure as of the alleged priority date.

52. I further understand that the fact that some experimentation may be

required for one of ordinary skill in the art to practice the claimed invention does not necessarily mean the patent fails to meet the enablement requirement. However, it is my understanding that the factors that may be considered in determining whether undue experimentation would be required to make and use the claimed invention include: the quantity of experimentation necessary, the amount of direction or guidance disclosed in the patent, the presence or absence of working examples in the patent, the nature of the invention, the state of the prior art, the relative skill of those in the art, the predictability of the art, and the breadth of the claims.

53. It is further my understanding that a patent need not expressly state information that skilled persons would be likely to know or could obtain.

54. I understand that the full scope of the claims must be enabled, such that the scope of the claimed invention is not greater than the scope of the invention enabled by the specification. I further understand that elements of a claim may not be enabled when the inventor was not able to implement the elements at the time of filing.

55. It is also my understanding that a patent can lack enablement of a given claim element by expressly teaching away from it.

F. Priority Date

56. I understand that the “priority date” of an invention is the date that determines whether a reference qualifies as prior art to the alleged invention. I

understand that the priority date is the date the patent application is filed, and that a patent application may claim priority to an earlier-filed application or applications. In order to successfully claim priority to an earlier-filed application, the earlier-filed application must provide (i) sufficient written description support and (ii) an enabling disclosure for the full scope of the later-claimed invention. If the earlier-filed application fails to provide sufficient written description or lacks an enabling disclosure for the full scope of the later-claimed invention, the patent is not entitled to the priority date of the earlier-filed application.

III. MATERIALS REVIEWED

57. As noted above, I have reviewed a number of materials in rendering the opinions in this Report. In preparing this declaration, I have considered the claims, specification, and prosecution history of the '405 patent. I have reviewed the Petition for *Inter Partes* Review (and exhibits, including the Declaration of James F. Shanley) filed by Petitioner Hesai Technology Co., Ltd. filed on September 14, 2023; Ouster's Patent Owner Preliminary Response (and exhibits) filed on December 21, 2023; and the Board's Institution Decision issued March 19, 2024. I have also reviewed the deposition transcript (and exhibits) in this proceeding of Dr. James F. Shanley, dated June 6, 2024. To the extent that materials cited in this declaration are not reflected in the above paragraph, I have also relied on any materials cited in this declaration in rendering my opinions.

IV. PERSON OF ORDINARY SKILL IN THE ART

58. I am informed and understand that the claims of a patent are judged from the perspective of a hypothetical construct involving a “person of ordinary skill in the art.” The “art” is the field of technology to which the patent is related. I understand that the purpose of using the viewpoint of a person of ordinary skill in the art is for objectivity. I understand that a person of ordinary skill in the art is presumed to know and be familiar with the relevant art in the field at the time of invention and is also presumed to possess an average level of creativity.

59. I understand that factors that may be considered in determining the level of ordinary skill include: (1) the type of problems encountered in the art at or prior to the relevant time period; (2) pre-existing solutions (i.e., prior art) to those problems; (3) the pace at which solutions innovations were developed at the relevant time period; (4) the sophistication of technology at the relevant time period; and (5) the education level of people working in the relevant field(s) at the relevant time period.

60. In my opinion, a POSITA would have had an undergraduate degree in mechanical or electrical engineering and two to three years of work experience with electro-optical and electro-mechanical devices or systems, with, at a minimum, at least one year of work experience was with LIDAR designs. My opinion as to a POSITA is based on my relevant academic and industry experience.

61. I have applied this level of skill to my analysis in this case. Based on my education and experience, I consider myself to have at least the necessary qualifications of a POSITA and have prepared all opinions set forth herein on the basis of that understanding. Furthermore, I frequently interact with, work with, supervise, and mentor persons with these qualifications.

62. I understand that Dr. Shanley asserted that a POSITA would have had “an undergraduate degree in mechanical or electrical engineering or physics and two to three years of experience in the field of LiDAR design. Less work experience may be compensated by a higher level of education or vice versa.” EX1003, ¶75. I also understand that Dr. Shanley testified that a POSITA would have been a team of engineers, including an optical engineer, an electrical engineer, and a mechanical engineer. EX2011, 57:3-58:21 (“[Y]ou have to have a team to put all these pieces together.”) I disagree with Dr. Shanley’s additional requirements related to LIDAR system design. In my opinion, a POSITA need only have at least one year of work experience with LIDAR designs—and another two to three years of work experience with electro-optical and electro-mechanical devices or systems. Given the ’405 patent’s focus on optical and mechanical aspects of the design of its disclosed systems, two to three years of work experience with electro-optical and electro-mechanical systems would have been sufficient for a POSITA in my opinion.

V. THE '405 PATENT

63. The '405 patent, titled "Spinning LIDAR Unit with Micro-Optics Aligned Behind Stationary Window," was filed on May 14, 2018 and has a priority date of May 15, 2017. It has three named inventors: Angus Pacala, Mark Frichtl, and Marvin Shu.

64. The '405 patent discloses embodiments of a novel narrowband imaging system. Recognizing that the performance of an optical filter to filter out wavelengths of light depends on the angle of incident light that reaches the filter, the '405 patent discloses the use of apertures to limit the angles of light that reach an optical filter. EX1001, 1:51-64. Further, recognizing the problem of cross-talk for an active illumination system, the '405 patent discloses the use of separate optical channels with dedicated aperture, filter, and detector array elements. *Id.*, 2:37-59. Additionally, the '405 patent discloses the use of single-photon avalanche diode arrays, or SPADs, as the photodetectors, given the importance of small and compact receivers that are relatively low in cost. *Id.*, 2:29-31.

65. The '405 patent discloses "optical imager systems that achieve wide field-of-view, narrowband imaging with micro-optic receiver channel arrays that minimize cross-talk and allow tight spectral selectivity that is uniform across the receiver channel array." EX1001, 2:63-67.

66. Figure 2 shows an exemplary light detection system:

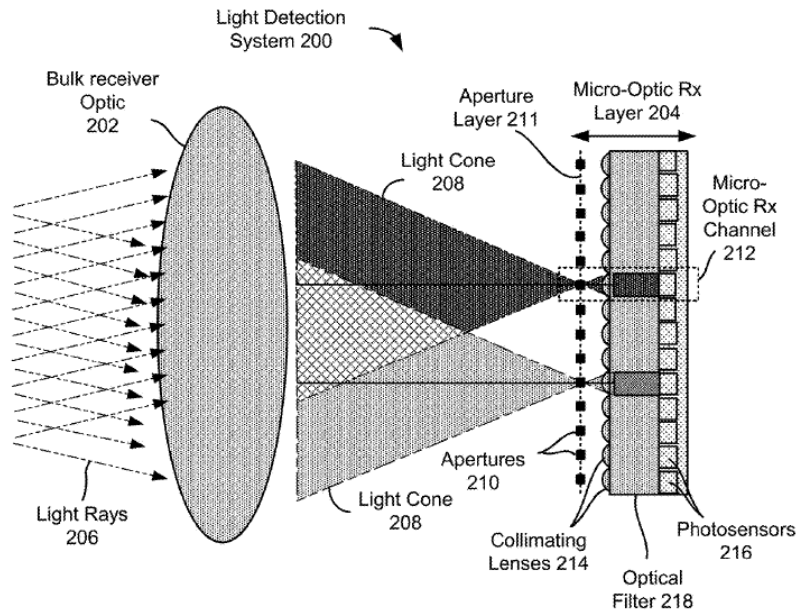


FIG. 2

EX1001, Fig. 2. Bulk receiver optic **202** focus received light into cones that converge on the various apertures of aperture layer **211**. *Id.*, 13:27-42. Light rays pass through the apertures, enter collimating lenses **214**, and reach optical filter **218**, which blocks unwanted wavelengths of light. *Id.*, 14:10-12. The performance of the optical filter as a bandpass filter is aided by micro-optic layer **204**, which leads to all rays entering the optical filter to be at approximately the same angle of incidence. *Id.*, 14:18-22. After filtering, light rays reach photosensors **216**, which can each be an array of multiple SPADs. *Id.*, 14:29-37.

67. Figure 4 shows a block diagram providing a high-level overview of an embodiment of the '405 patent invention, including sensing and transmission modules:

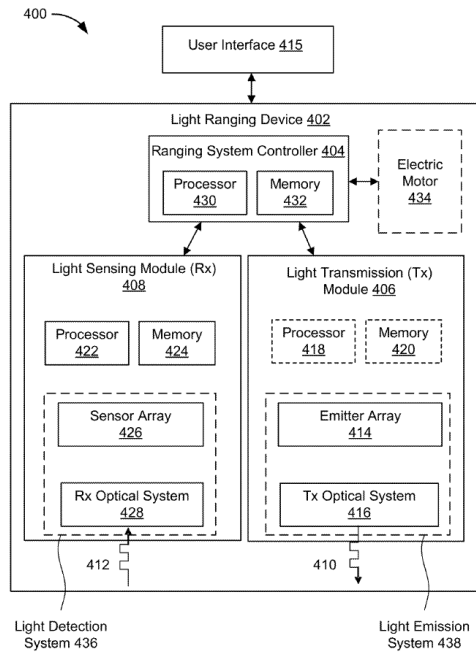


FIG. 4

EX1001, Fig. 4.

68. Figure 8 illustrates the relationship between emitter and receiver channels in embodiments of the '405 patent:

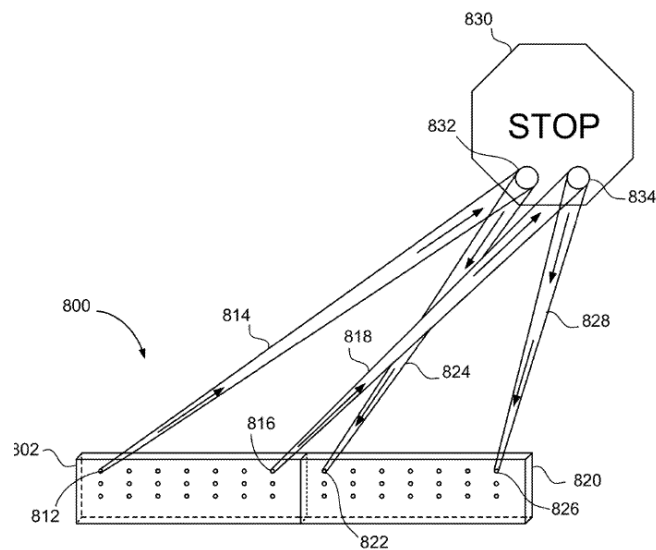


FIG. 8

EX1001, Fig. 8. “The light emitter array **810** includes an array of light emitters, e.g., an array of vertical cavity surface-emitting lasers (VCSELs) and the like, such as emitter **812** and emitter **816**.” *Id.*, 21:49-52. “Each emitter can be slightly offset from its neighbor and can be configured to transmit light pulses into a different field of view from its neighboring emitters[.]” *Id.*, 21:59-63. Thus, there is a “one-to-one mapping between the set of emitters and the set of non-overlapping fields [of] view.” *Id.*, 22:8-12. Further, each sensor has a different field of view than its neighbor. *Id.*, 22:19-24. “Because the fields of view of the emitters are overlapped with the fields of view of their respective sensors, each receiver channel ideally can detect the reflected illumination beam that originates from its respective emitter channel with ideally no cross-talk, i.e., no reflected light from other illuminating beams is detected.” *Id.*, 22:36-41.

A. Challenged Claims

69. I understand that Petitioner is challenging claims 21 and 23-34 of the ’405 patent, reproduced below:

Claim 21
21(a) An optical system for performing distance measurements, the optical system comprising:
21(b) a stationary housing having a base, a top and an optically transparent window disposed between the base and the top and extending fully around a periphery of the stationary housing;
21(c) a light ranging device disposed within the housing and comprising:
21(d) a platform;
21(e) a light transmission module coupled to the platform and comprising a bulk transmitter optic and a plurality of optical emitters, each optical emitter in the

plurality of optical emitters configured to generate and transmit pulses of radiation through the bulk transmitter optic and through the optically transparent window into a field external to the optical system; and
21(f) a light sensing module coupled to the platform and comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and an optical filter disposed between the bulk receiver optic and the plurality of photosensors and configured to allow a band of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the filter to the plurality of photosensors while blocking radiation outside the band from reaching the plurality of photosensors; and
21(g) a motor disposed within the housing and operatively coupled to spin the platform and the light ranging device within the housing;
21(h) wherein: each photosensor in the plurality of photosensors comprises a plurality of single photon avalanche diodes (SPADs);
21(i) the plurality of apertures comprises at least first, second, third and fourth apertures;
21(j) the plurality of photosensors comprises at least first, second, third and fourth photosensors; and the light sensing module includes a first optical path to the first photosensor through the first aperture, a second optical path to the second photosensor through the second aperture, a third optical path to the third photosensor through the third aperture, and a fourth optical path to the fourth photosensor through the fourth aperture.
Claim 23
The optical system for performing distance measurements according to claim 21 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of optical emitters and detection of photons from the pulses of light by the plurality of photosensors.
Claim 24
The optical system for performing distance measurements according to claim 21 wherein the plurality of optical emitters are arranged to form a plurality of emitter channels having non-overlapping fields of view, and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping the fields of view and having a one-to-one relationship with the plurality of emitter channels such that the field of view for each receiver channel is coincident with the field of view of a corresponding emitter channel.

Claim 25
The optical system for performing distance measurements according to claim 21 wherein the plurality of emitters are configured to project a plurality of illuminating beams in the field external to the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of photosensors.
Claim 26
26(a) An optical system for performing distance measurements, the optical system comprising:
26(b) a stationary housing having a base, a top and an optically transparent window disposed between the base and the top and extending fully around a periphery of the stationary housing;
26(c) a light ranging device disposed within the housing and comprising:
26(d) a platform;
26(e) a light transmission module coupled to the platform and comprising a bulk transmitter optic and a plurality of optical emitters, each optical emitter in the plurality of optical emitters configured to generate and transmit pulses of radiation through the bulk transmitter optic and through the optically transparent window into a field external to the optical system; and
26(f) a light sensing module coupled to the platform and comprising a bulk receiver optic, an aperture layer comprising a plurality of apertures separated by a stop region, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and one or more optical filters disposed between the bulk receiver optic and the plurality of photosensors, each of the one or more optical filters configured to allow a set of wavelengths of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the one or more optical filters while blocking radiation outside that set; and
26(g) a motor disposed within the housing and operatively coupled to spin the platform and the light ranging device within the housing;
26(h) wherein: each photosensor in the plurality of photosensors comprises a plurality of single photon avalanche diodes (SPADs);
26(i) the plurality of apertures comprises at least first, second, third and fourth apertures;
26(j) the plurality of photosensors comprises at least first, second, third and fourth photosensors; and the light sensing module includes a first optical path to the first photosensor through the first aperture, a second optical path to the second

photosensor through the second aperture, a third optical path to the third photosensor through the third aperture, and a fourth optical path to the fourth photosensor through the fourth aperture.
Claim 27
The optical system for performing distance measurements set forth in claim 26 wherein the one or more optical filters comprise a bandpass filter.
Claim 28
The optical system for performing distance measurements set forth in claim 26 wherein the one or more optical filters comprise a plurality of optical filters.
Claim 29
The optical system for performing distance measurements set forth in claim 28 wherein each of the plurality of optical filters is supported by an optically transparent substrate.
Claim 30
The optical system for performing distance measurements set forth in claim 29 wherein the plurality of optical filters are disposed in the first optical path.
Claim 31
The optical system for performing distance measurements according to claim 26 wherein the system generates distance data based on times between transmission of pulses of light from the plurality of optical emitters and detection of photons from the pulses of light by the plurality of photosensors.
Claim 32
The optical system for performing distance measurements according to claim 26 wherein the plurality of optical emitters are arranged to form a plurality of emitter channels having non-overlapping fields of view, and the plurality of photosensors are arranged to form a plurality of receiver channels having non-overlapping fields of view and having a one-to-one relationship with the plurality of emitter channels such that the field of view for each receiver channel is coincident with the field of view of a corresponding emitter channel.
Claim 33
The optical system for performing distance measurements according to claim 26 wherein the plurality of emitters are configured to project a plurality of illuminating beams in the field external to the optical system according to an illumination pattern that substantially matches, in size and geometry across a range of distances from the system, a plurality of non-overlapping fields of view of the plurality of photosensors.
Claim 34
The optical system for performing distance measurements according to claim 26 wherein the one or more optical filters comprises a first optical filter disposed in

the first optical path between the first photosensor and the first aperture, a second optical filter disposed in the second optical path between the second photosensor and the second aperture, a third optical filter disposed in the third optical path between the third photosensor and the third aperture, and a fourth optical filter disposed in the fourth optical path between the fourth photosensor and the fourth aperture.

VI. DR. SHANLEY'S ASSERTED PRIOR ART

70. Below are summaries of the prior art Dr. Shanley is asserting in this IPR that I discuss at length in this declaration.

A. Pacala

71. U.S. Patent Application Publication No. 2014/0211194 A1 (“Pacala”) is a patent application that discloses “[a] lidar-based apparatus and method” using “a multi-channel time-to-digital converter (TDC) electronic circuit, with each TDC having an individually adjustable voltage threshold.” EX1004, [0010].

72. Figure 1 of Pacala shows an external view of a LIDAR sensor with a static base **20** and a static head **30**:

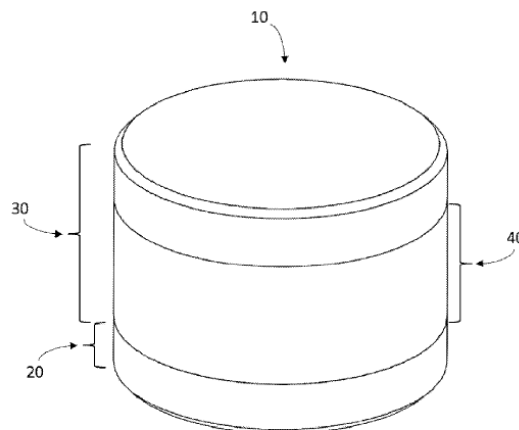


Fig. 1

EX1004, Fig. 1.

73. Figure 2 of Pacala shows an internal view of the LIDAR sensor with the base and head removed:

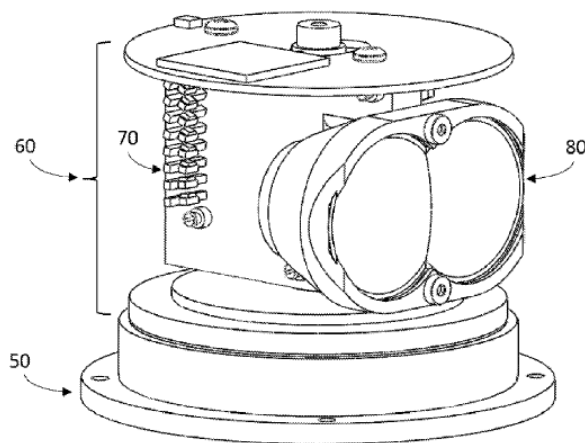


Fig. 2

Id., Fig. 2. The internal view shows “a static base **50** that contains a motor and distributed electronics, and a spinning turret **60** that contains optoelectronic components **70** (including optical transmitters and receivers), collimation and focusing lenses **80** and distributed electronics.” *Id.*, [0013].

74. Much of the written description of Pacala is dedicated to discussion of the time-to-digital converter (TDC) electronic circuitry of a LIDAR sensor. *Id.*, [0014]. The final sentence of Pacala’s specification states: “The multi-channel TDC electronic circuitry with multiple voltage thresholds can be implemented with discrete integrated circuits (ICs), in the form of FPGA logic, as part of an application-specific integrated circuit (ASIC), or integrated into the pixels of a

detector array (e.g., Single-Photon Avalanche Diode [SPAD] array).” *Id.* This parenthetical in the last sentence of Pacala’s specification is the only disclosure of the use of single-photon avalanche diodes, or SPADs. EX2011, 44:16-45:2 (“Q. And so you said that Pacala’s teaching of the use of SPADs comes at the end of Paragraph 14. Is there any other teaching of SPADs in Pacala, Exhibit 1004? A. No.”)

B. Droz

75. U.S. Patent No. 10,605,984 (“Droz”) is a patent that discloses waveguides for use in an optical receiver system. Figure 3B shows an array of waveguides:

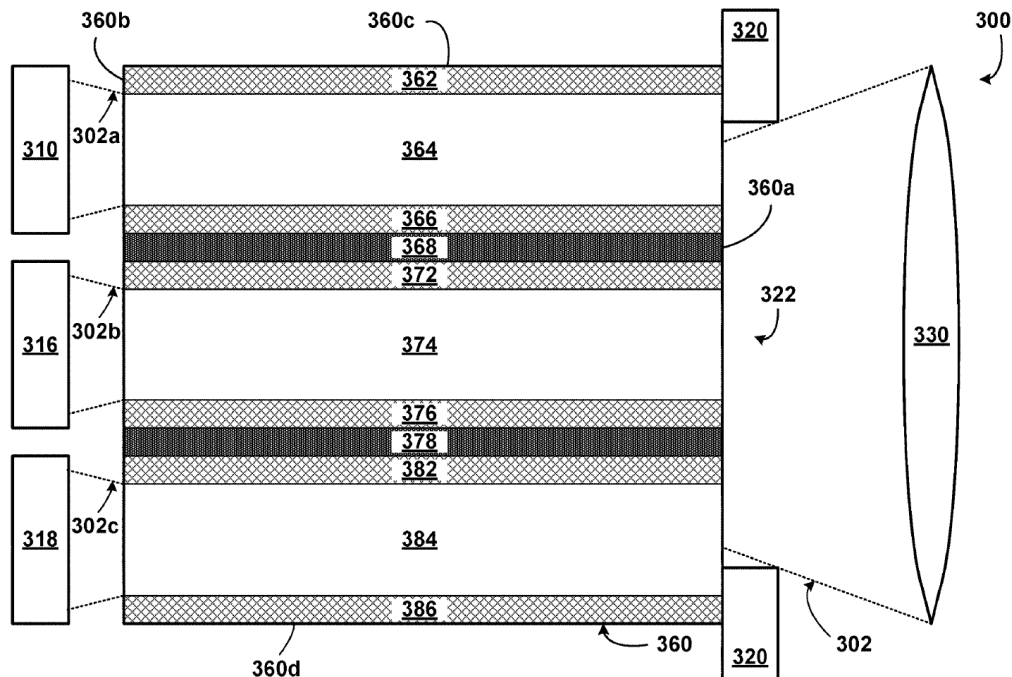


FIG. 3B

EX1006, Fig. 3B. The waveguides consist of multiple layers. Core layers **364, 374,**

and **384** “may comprise a relatively high index of refraction material, such as a glass or high-index polymer substrate[,] for instance, that is transparent to at least some wavelengths of light **302**.” *Id.*, 13:35-38. Cladding layers **362**, **366**, **372**, **376**, **382**, and **386** “may comprise a relatively low index of refraction material, such as polymer coated or fluorine-doped glass substrates for instance.” *Id.*, 13:31-34. Further, absorbing layers **368** and **378** “may comprise an absorber formed from any material suitable for absorbing wavelengths of light **302** guided within waveguide array **360**.” *Id.*, 13:39-41. Each waveguide receives a portion of light **302** from lens **330** and “guide[s] the [] portion of light **302**, via total internal reflection for instance, toward and out of an output end” as diverging light **302a**, **302b**, and **302c**. *Id.*, 14:4-17.

76. Droz only discloses using its waveguides in stationary applications—not in applications involving scanning or rotation. The only reference in Droz to any movable portion is the discussion that the system can adjust the angle of element **320** or array **360** with respect to other elements in the system like lens **330**, including via the movement of an actuator. *Id.*, 16:5-10. A POSITA would not have understood such movement as scanning or rotation for purposes of detecting a scene, but rather as mere adjustment of the spatial relationship between components in Droz’s system.

C. Hall

77. U.S Patent No. 9,983,297 (“Hall”) discloses “[m]ethods and systems

for performing three dimensional LIDAR measurements with varying illumination field density[.]” EX1008, Abstract.

78. Hall incorporates by reference U.S. Patent No. 7,969,558 (“Hall ’558”; EX2012), indicating that it discloses “a 3-D LIDAR system . . . that includes an array of multiple laser emitters and detectors.” EX1008, 2:9-14. The only detector that Hall ’558 discloses for the LIDAR system is avalanche photo diodes, or APDs. EX2012 (Hall ’558), 5:28-31 (“[T]he detection circuitry consists of high speed A-D’s[.]”), 5:6-7 (“[T]he photo diode is preferably an Avalanche variety, but other types can be used.”). The APDs disclosed in Hall ’558 and incorporated by reference by Hall are the only detector identified for the Hall system.

79. Hall discloses that LIDAR systems capture “point cloud” of a “collection of pixels emitted and captured in rapid succession” and “rendered as an image[.]” EX1008, 2:17-21. Hall indicates that “imaging resolution depends on the density of the 3-D ‘point cloud’ generated by the LIDAR system.” *Id.*, 2:34-35. “Oftentimes, to improve imaging resolution, the density of the 3-D ‘point cloud’ is increased by increasing the rate of pulse emission and capture of corresponding return signals.” *Id.*, 2:36-38. Hall states that “[i]mprovements in power management of LIDAR systems are desired, while maintaining sufficiently high levels of imaging resolution and range.” *Id.*, 2:46-48.

80. Hall discloses embodiments in which “a pulsed illumination source and

photosensitive detector are mounted to a rotating frame of the LIDAR device.” EX1008, 2:59-61. The rotating frame rotates with respect to a base frame. *Id.*, 2:61-62. Hall discloses that the LIDAR system can be mounted to a vehicle operating on a roadway, with a point cloud being generated regarding the vehicle’s surroundings. *Id.*, 3:3-19.

81. Figure 2 of Hall shows an embodiment of Hall’s rotating LIDAR system:

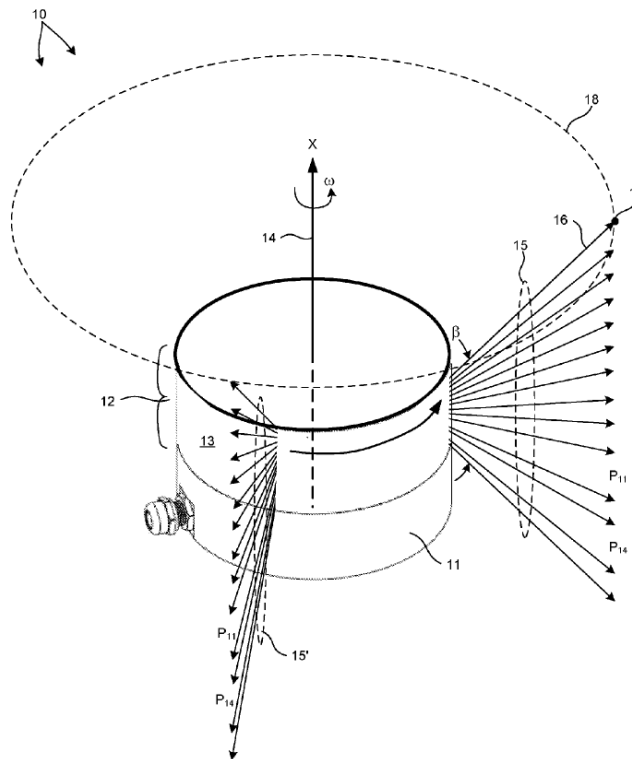


FIG. 2

EX1008, Fig. 2. “As the beams of light **15** rotate about central axis **14**, each beam of light projected into the surrounding environment (e.g., each cone of illumination

light associated with each beam) illuminates a volume of the environment corresponding the cone shaped illumination beam as it is swept around central axis 14.” *Id.*, 6:4-9.

82. Figure 3 shows an exploded view of an embodiment of Hall’s rotating LIDAR system:

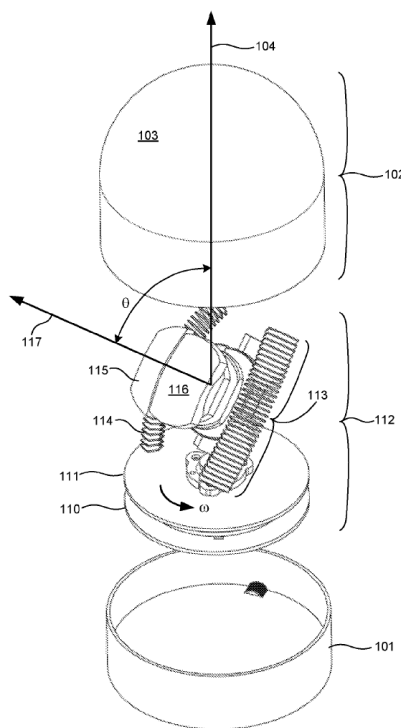


FIG. 3

EX1008, Fig. 3. Hall discloses that rotating electronics board rotates at a predetermined rotational velocity—“e.g., more than 200 revolutions per minute”—and light emitters and detectors are fixed to the rotating electronics board and rotated with the board. *Id.*, 6:18-22, 6:27-30.

83. Hall discloses means for reducing cross-talk in its system. Hall

discloses that the delay time between a first emitter and a second emitter emitting a light pulse can be “set to be greater than the time of flight of the measurement pulse sequence to and from an object located at the maximum range of the LIDAR device.” EX1008, 9:13-17. Hall discloses that if its system is operated with such a delay time, “there is no cross-talk among any of the sixteen multi-pulse illumination systems.” *Id.*, 9:13-17. Hall also discloses that if its system is operated without the delay time such that there is temporal overlap between pulses emitted from different emitters, then “care is taken to ensure that there is sufficient spatial separation between the areas of the surrounding environment interrogated by each beam to avoid cross-talk.” *Id.*, 9:18-25.

D. Borowski

84. U.S. Patent Application Publication No. 2013/0300840 A1 (“Borowski”) discloses a 3D landscape real-time imager using “an ultra-short laser pulse source” and a set of SPAD detector arrays. EX1009, Abstract.

85. Borowski discloses that its device “illuminates quickly rotating vertical lines in the landscape with ultra-short, ultra-high peak power infrared light pulse trains. The reflected photons are efficiently detected on linear arrays of ultrafast SPAD sensors at gigahertz pulse repetition frequencies.” *Id.*, [0022]. Borowski discloses that the ultra-short laser pulses have a pulse width of 1 picosecond. *Id.*, [0065].

86. Borowski further discloses that SPADs are accompanied by quenching circuits. *Id.*, [0036], [0051].

87. Borowski discloses that “[s]ome of the SPAD sensors in the optical rotating device **33** could be replaced and/or combined with ultra-fast video sensors.” *Id.*, [0081].

E. Spector

88. U.S. Patent No. 10,473,766 (“Spector”) discloses a LIDAR system that creates a two-dimensional array of light spots using micro-optic and aperture arrays and “causes the array of light spots to move back and forth so as to complete a scan of the scene.” EX1005, Abstract.

89. I understand that Dr. Shanley is relying on provisional application No. 62/470,706 in support of the alleged priority of Spector over the ’405 patent. I also understand that unless Spector can claim support from provisional application No. 62/470,706, Spector is not prior art to the ’405 patent.

90. Figure 1 of Spector is reproduced below:

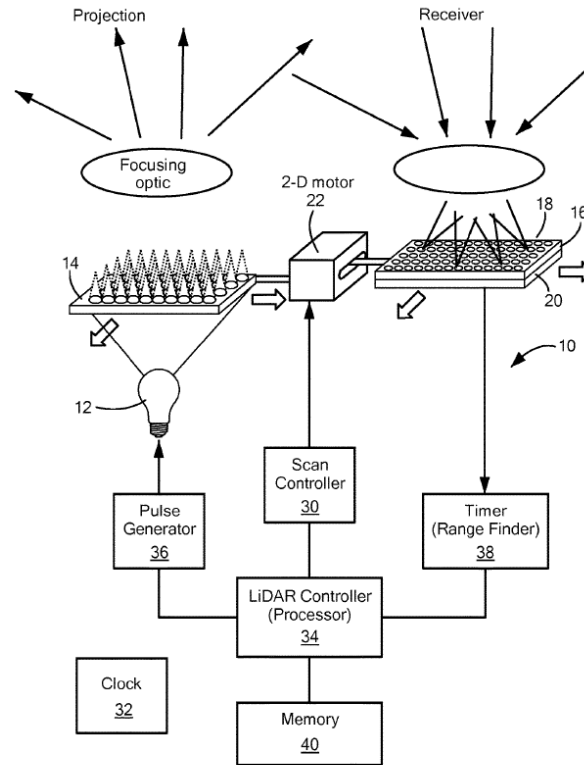


FIG. 1

EX1005, Fig. 1. Spector discloses that a single light source **12** transmits light through an arrayed micro-optic **14**. *Id.*, 3:1-3. Further, Spector discloses that “an array of optical detection sites are formed in receiver optics **16**.” *Id.*, 3:32-34. These detection sites are “configured for establishing a one-to-one correspondence between the light spots in the two dimensional array and the optical detection sites.” *Id.*, 3:34-37. Spector discloses using aperture arrays, but only for detectors that have a high fill factor. *Id.*, 3:49-56.

91. The arrayed micro-optic **14** and the receiver optics **16** are “synchronously scanned so that correspondence is maintained between the spots in the two dimensional array and the optical detection sites.” EX1005, 3:62-65. A scan

controller **30** “operates to cause the scanner **22** to move the array of light spots back and forth so as to complete a scan of the scene.” *Id.*, 4:55-57. This back-and-forth scanning motion is shown in Figure 9, reproduced below:

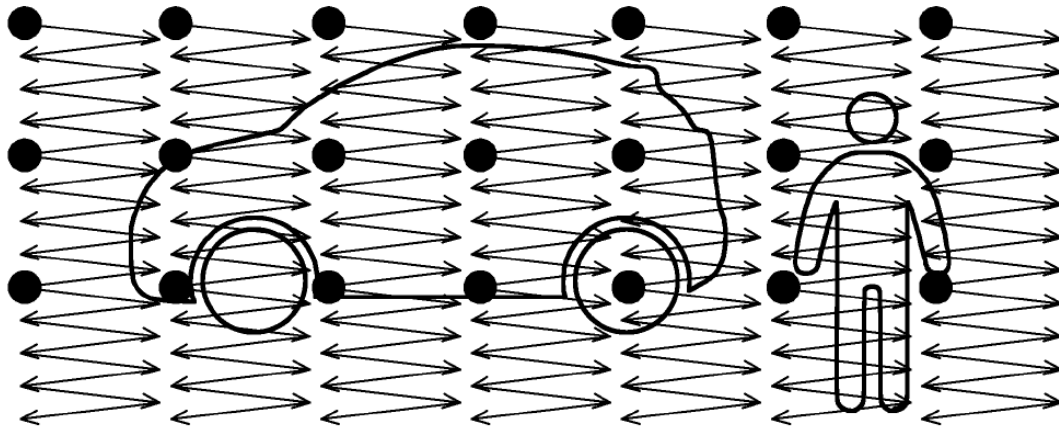


FIG. 9

Id., Fig. 9. “By using a two dimensional array of light spots over a wide field of view and by limiting the movement in each direction to the distance between spots (or with some overlap), the mechanical movement of the scanner **22** is minimized and yet a complete scan of the scene is accomplished.” *Id.*, 5:8-12. “When the scene has been scanned, a three-dimensional reconstruction **160** of the scene can be completed.” *Id.*, 6:8-10.

VII. DR. SHANLEY’S GROUNDS

92. Dr. Shanley opines that the challenged claims are obvious based on four grounds: (1) claims 21, 23, 26-31, and 34 over Pacala and Droz (ground 1); (2) claims 24-25 and 32-33 over Pacala, Droz, and Villeneuve (ground 2); (3) claims 21

and 23-33 over Hall, Borowski, and Spector (ground 3); and (4) claim 34 over Hall, Borowski, Spector, and Droz (ground 4). I disagree with Dr. Shanley that the challenged claims would have been obvious to a POSITA over any of his asserted prior art grounds.

A. Ground 1: Claims 21, 23, 26-31, and 34 over Pacala and Droz

93. Dr. Shanley asserts that claims 21, 23, 26-31, and 34 would have been obvious over Pacala in light of Droz. I disagree with Dr. Shanley for the reasons provided below.

1. For limitations 21(f) and 26(f), the Pacala-Droz combination does not satisfy a “plurality of apertures separated by a stop region”

94. Limitation 21(f) of claim 21 requires “light sensing module coupled to the platform and comprising a bulk receiver optic, **an aperture layer comprising a plurality of apertures separated by a stop region**, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and an optical filter disposed between the bulk receiver optic and the plurality of photosensors and configured to allow a band of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the filter to the plurality of photosensors while blocking radiation outside the band from reaching the plurality of photosensors[.]”

95. Similarly, limitation 26(f) of claim 26 requires “a light sensing module coupled to the platform and comprising a bulk receiver optic, **an aperture layer comprising a plurality of apertures separated by a stop region**, a plurality of photosensors operable to detect photons emitted from the plurality of optical emitters and received through the bulk receiver optic after being reflected from surfaces within the field, and one or more optical filters disposed between the bulk receiver optic and the plurality of photosensors, each of the one or more optical filters configured to allow a set of wavelengths of radiation, including an operating wavelength of the plurality of optical emitters, to pass through the one or more optical filters while blocking radiation outside that set[.]”

96. Dr. Shanley asserts that “Droz’s waveguide array in the Pacala-Droz combination provides an aperture layer.” EX1003 ¶150. Droz’s waveguides consist of three layers—core layers, cladding layers, and absorbing layers. EX1006, 13:31-41. Dr. Shanley asserts that the core and cladding layers of each waveguide is an aperture. EX1003 ¶¶150-51. Further, Dr. Shanley asserts that the absorbing layers “provide a stop region between the apertures, by preventing light from passing through where the absorbing layers are placed (including between adjacent waveguides).” *Id.* ¶151.

97. The sole basis for Dr. Shanley’s opinion that Droz discloses apertures separated by a “stop region” is that Droz’s absorbing layers (368, 378) as shown in

Figure 3B prevent light from passing between different waveguides. EX1003 ¶151.

I have prepared the below demonstrative using Droz's Figure 3B to show what Dr. Shanley considers to be Droz's stop region:

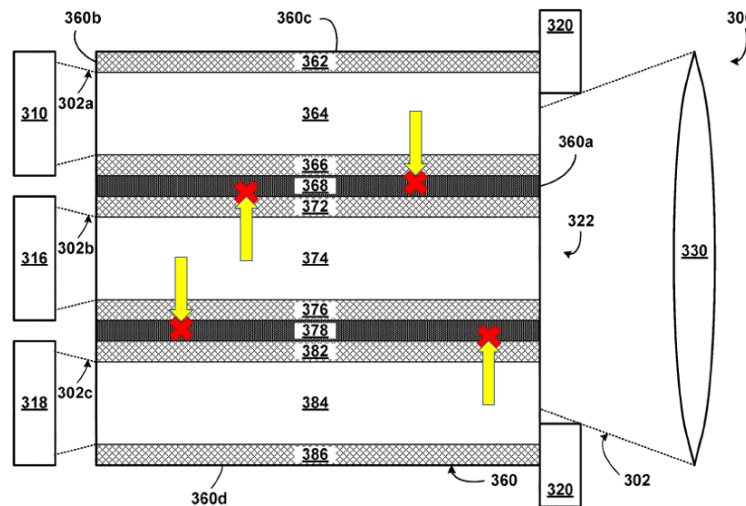


FIG. 3B

98. I disagree with Dr. Shanley that Droz discloses “an aperture layer comprising a plurality of apertures separated by a stop region.” Clms. 21(f), 26(f). The absorbing layers 368 and 378, as shown in Figure 3B, do not qualify as a stop region as recited in the claim for the reasons provided below.

99. Dr. Shanley's opinion that Droz discloses a “stop region” is based on an incorrect claim construction. When asked at his deposition, Dr. Shanley testified that he understood the term “stop region” to refer to an element that “stops light from propagating in that area.” EX2011, 53:7-10. But this interpretation of “stop region,” in my opinion, is overbroad and incorrect. Dr. Shanley has thus failed to identify an aperture layer comprising a plurality of apertures separated by a stop region, under

a proper construction.

100. The correct construction for “stop region” is an optically non-transparent region that defines a field of view for a photosensor, and I will explain the basis of this construction below. Dr. Shanley has not identified “an aperture layer comprising a plurality of apertures separated by a stop region,” under this construction. Droz’s waveguides instead have cladding layers 362, 366, 372, 376, and 386 that are reflective. EX1006, 14:23-33; EX1003, ¶150 (discussing “cladding layers . . . that reflect light that reaches the edge of the core layer in order to guide it along the path defined by the waveguide”). Accordingly, if a light ray enters a Droz waveguide from an angle, it is reflected along the course of the waveguide and is not stopped:

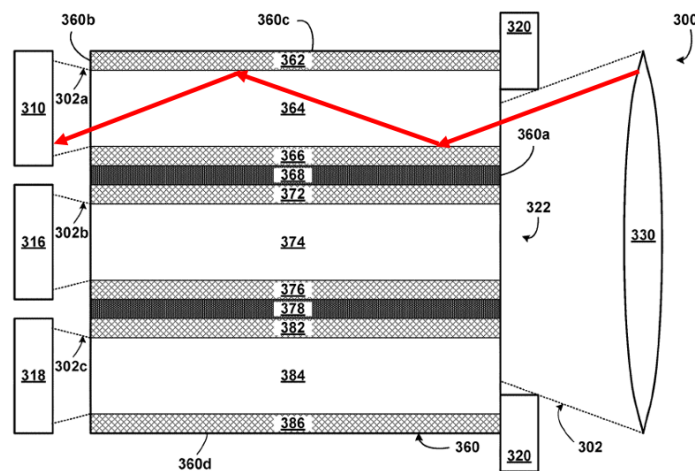
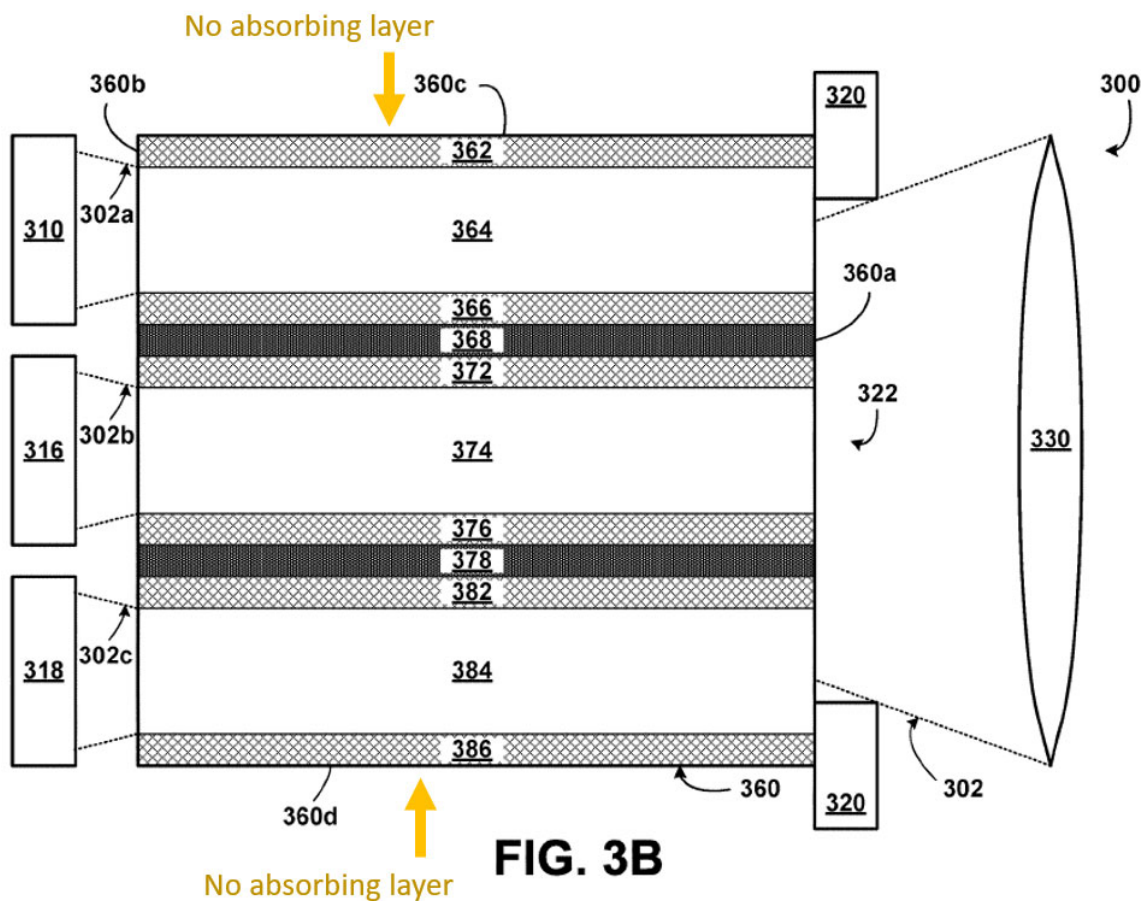


FIG. 3B

EX1006, Fig. 3B (colored annotations added). As seen above, Droz’s reflective waveguides and absorbing layers 368 and 278 do not determine a field of view for a detector as do the stop regions of the apertures in the ’405 patent. They are instead

designed to accept and guide light from all angles to its photodetectors—they do not block light from certain angles to determine a field of view.

101. Particularly telling for the role of the absorbing layers in the Droz waveguides is that they are not even included on the outer edge of the top or bottom waveguides in Figure 3B:



EX1006, Fig. 3B (colored annotations added). If the absorbing layers served as a stop region properly construed—*i.e.*, they defined the field of view for the photosensors—then a POSITA would have expected that *each* waveguide would be surrounded by a pair of absorbing layers (on top and bottom). But Droz shows that

these absorbing layers are only placed *between* waveguides. EX1006, 16:35-36 (discussing “absorbers 368 and 378 appropriately inter-posed between the various waveguides”). For the waveguides on the top and bottom of the unit that only neighbor another waveguide on one side, only *one* absorbing layer is used. For the outer edge of these waveguides, the path of light entering the system is not restricted at all—it can enter the waveguide anywhere along the exposed outer edge of the waveguide. These outer waveguides confirm that the absorbing layers **368** and **378** are *only* for preventing leakage between waveguides—not for defining the field of view of a photosensor. This is further supported by the fact that the shape of the various layers, and even the presence or absence of the cladding and absorbing layers, is left open-ended by Droz. *Id.*, 16:40-42, 15:13-20. In other words, the absorbing layers are not essential elements of the Droz system, but rather optional elements that may vary based on the shape of the waveguides or other design variations.

102. The '405 patent specification states that a stop region defines the field of view of an aperture by preventing certain light from entering the aperture. For example, the '405 patent discloses “[a]n input aperture layer **1740** including an optically transparent aperture **1744** and optically non-transparent stop region **1746** configured to define a narrow field of view when placed at the focal plane of an imaging optic[.]” EX1001, 37:17-23 (emphasis added); *see also id.*, 40:56-59

(aperture “defines the maximal cylinder of light desired to be passed” and stop region absorbs or reflects light “outside the diameter” of the aperture), 41:13-17, 41:21-25, 42:7-10, 42:16-20. Figure 17 of the ’405 patent, reproduced below, shows stop region **1746** defining the field of view for photosensor **1771**. Marginal ray lines **1733** represent the outermost angles of light in the field of view defined by stop region **1746**. *Id.*, 37:23-25. Light rays that reach aperture **1744** from a more extreme angle (*i.e.*, an angle further from vertically oriented in Figure 17) cannot enter the aperture, because they are blocked by stop region **1746**. Based on this operation, the stop region **1746** defines the field of view for photosensor **1771**.

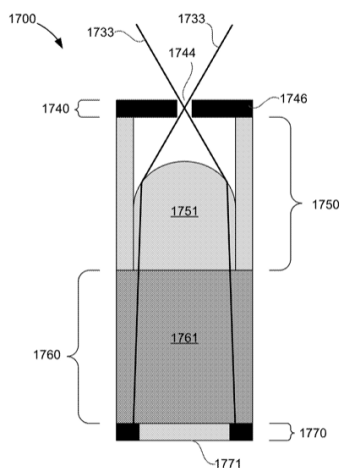


FIG. 17

(EX1001, Fig. 17.)

103. The ’405 patent specification indicates that there are other optically non-transparent regions in Figure 17—but these are *not* “stop regions.” For example, optical lens layer **1750** shown above may optionally include “non-transparent regions and tube structures to reduce cross talk.” EX1001, 37:46-49.

These are shown in blue in Figure 17 below:

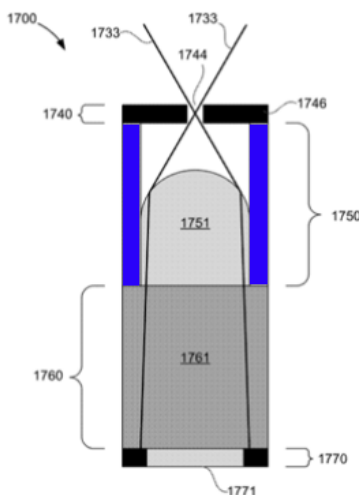
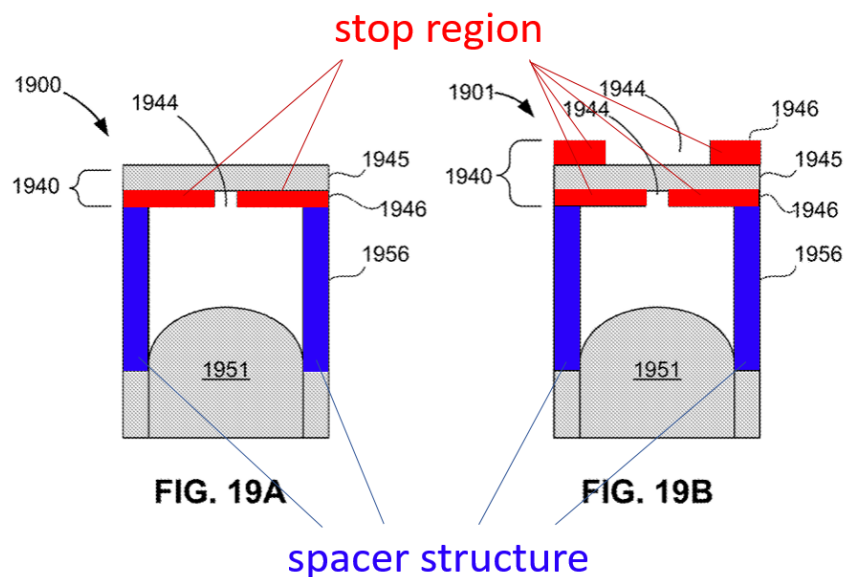


FIG. 17

EX1001, Fig. 17 (blue emphasis added). Optical lens layers 1750 are analogous to and serve the same purpose as absorbing layers 368 and 378 in Figure 3B of Droz above. But notably, the '405 patent never suggests that optical lens layers 1750 qualify as stop regions. It is simply a non-transparent region or tube structure that stops light propagating in an area (sideways either in or out of optical lens layer 1750). They do not qualify as stop regions because they do not define the field of view for an aperture. A POSITA would not have understood optically non-transparent regions that stop light for other purposes—*e.g.*, to prevent cross talk downstream from an aperture—as “stop regions.” This is confirmed by the specification of the '405 patent, which merely refers to these downstream structures as “optically non-transparent regions and tube structures”—not as “stop regions.” EX1001, 37:46-49.

104. Similarly, when discussing the embodiments shown in Figures 19A and 19B, the '405 patent indicates that the “stop region” is element **1946**—which is optically non-transparent material that defines the field of view for the aperture. EX1001, 39:42-46, 39:57-59. The '405 patent refers to the structure that follows the aperture and serves to “prevent[] any light from traveling outside the receiver channel” as “[o]ptically non-transparent spacer structure **1956**[.]” *Id.*, 39:29-46, 39:47-59. In other words, the '405 patent does not use the term “stop region” to refer to any optically non-transparent region. Rather, the '405 patent uses the term “stop region” only to refer to an optically non-transparent region that defines the field of view of an aperture. Optically non-transparent regions used for other purposes—for example, to prevent light from escaping a receiver channel—are *not* referred to as stop regions. Figures 19A and 19B are reproduced below, with labels added for stop regions **1946** and optically non-transparent spacer structure **1956**:



EX1001, Figs. 19A-B (colored annotations added).

105. The '405 patent specification provides no support for Dr. Shanley's understanding that a stop region is a material that stops light from entering any region for any purpose. For example, Figure 21E (reproduced below) shows multiple apertures and corresponding stop regions for various parallel optical channels. The '405 patent specification indicates that the apertures and stop regions act to limit field of view, disclosing that "apertures **2157** and corresponding non-transparent stop regions **2159** define a light cone for every lens set **2191** and function to absorb or reflect any stray light traveling a path not encompassed by the desired light cones." EX1001, 44:17-21. However, there is *no* suggestion that the stop regions work to keep light from moving between the parallel optical channels.

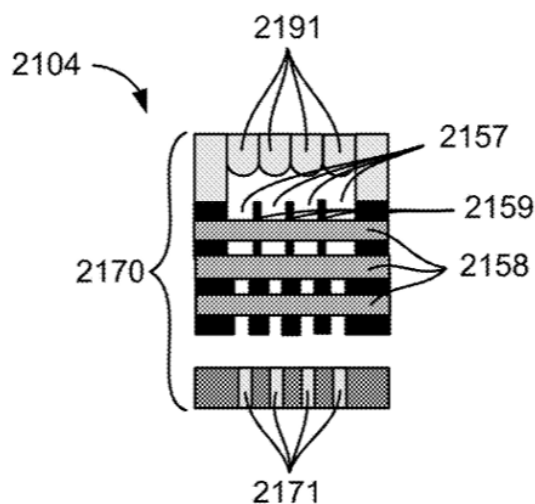


FIG. 21E

EX1001, Fig. 21E.

106. Further disclosures of the '405 patent specification that confirm the role

of the claimed “stop region[s]” are the repeated discussions of stop regions made out of extremely thin material like a metal film or foil. For example, the ’405 patent specification discusses “optically transparent aperture **1744** and optically non-transparent stop region **1746**” formed from “a metal foil with a pinhole[.]” EX1001, 38:36-39. The ’405 patent specification further discloses that “[s]elf-supported aperture layer **2240** can overhang concave hemisphere **2267** and can be perforated or etched with an optically non-transparent rigid material (e.g. metal film) to form the optically non-transparent stop regions **2246**.” *Id.*, 48:25-29. A POSITA would have understood that such a thin stop region as one formed out of a thin metal sheet clearly has no role in preventing light from moving from one channel to another, because the material that would prevent such lateral motion is so thin that virtually no light would be stopped in the side-to-side direction between apertures.

107. The use of the term “stop region” in the ’405 patent is consistent with how persons of ordinary skill in the art understood the term. For example, Frank L. Pedrotti et al., *Introduction to Optics* (3d ed. 2006) states:

The *aperture stop* of an optical system is the actual physical component that limits the size of the *maximum cone* of rays—from an axial object point to a conjugate image point—that can be processed by the entire system. Thus it controls the brightness of the image. The diaphragm of a camera and the iris of the human eye are examples of aperture stops. Another example is found in the telescope, in which the first, or objective, lens determines how

much light is accepted by the telescope to form a final image on the retina of the eye.

EX2007, p. 51. The description in Pedrotti is consistent with the '405 patent. For example, Figure 17 of the '405 patent (reproduced above) shows the maximum cone of rays (highlighted below) that can enter aperture **1744** due to stop region **1746**:

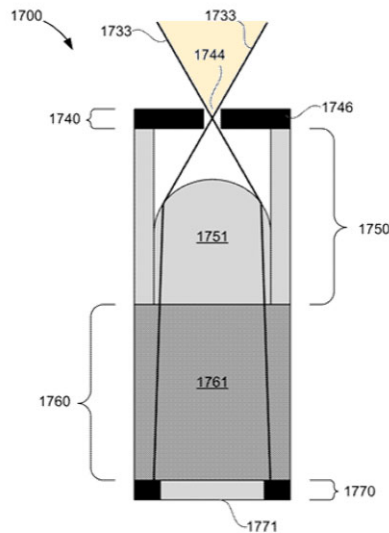


FIG. 17

EX1001, Fig. 17 (colored annotations added), 38:36-41.

108. Similarly, Warren J. Smith, *Practical Optical System Layout and Use of Stock Lenses* (1997) provides the following description:

We begin with a discussion of an often neglected but vital aspect of optical systems, the concept of the *aperture stop*. In every optical system there is some feature, usually a diameter, which limits the size or diameter of the beam of rays which can pass through the system. If the system consists of just a single simple lens, the aperture stop is just the clear aperture of the lens. In a typical camera

lens the iris diaphragm is the aperture stop. In a telescope the clear aperture of the objective lens (or that of the primary mirror) is ordinarily the aperture stop. Often the aperture stop is referred to simply as “the stop.”

EX2013, p. 49.

109. The absorbing layers of Droz’s waveguides do not define a field of view like the stop regions claimed by the ’405 patent and as understood by a POSITA. The ’405 patent’s stop regions define a field of view by blocking light coming into the system at certain angles. For example, Figure 17 of the ’405 patent shows two marginal light rays **1733** entering an aperture:

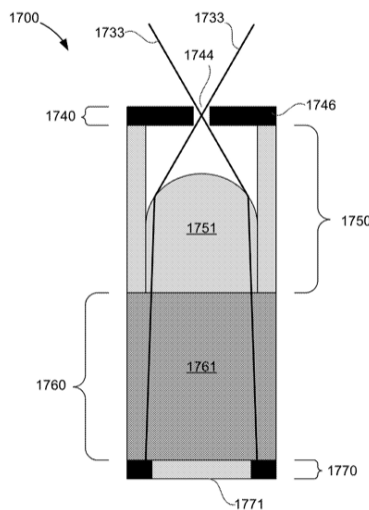
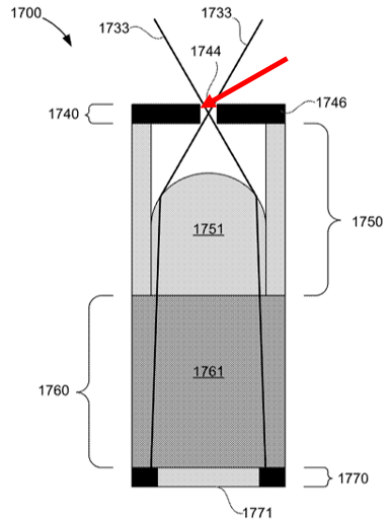


FIG. 17

EX1001, Fig. 17. These are marginal light rays because they represent the most extreme angles at which light rays can enter the aperture. If a light ray enters the system at a more extreme angle, then it is blocked by the stop region **1746**, as shown in the below demonstrative figure:



EX1001, Fig. 17 (colored annotation added). Droz’s waveguides do not work this way, because as explained, they have cladding layers that are reflective. EX1006, 14:23-33; EX1003, ¶150 (discussing “cladding layers . . . that reflect light that reaches the edge of the core layer in order to guide it along the path defined by the waveguide”). Accordingly, if a light ray enters a Droz waveguide from an angle, it is reflected along the course of the waveguide and is not stopped:

EX1006, Fig. 3B (colored annotations added). As a result, Droz's waveguides do not determine a field of view for a detector as do the stop regions of the apertures in the '405 patent. Instead, Droz's waveguides are designed to accept and guide light from all angles to its photodetectors—not blocking out light from certain angles to determine a field of view. Accordingly, Droz's waveguides operate differently from the apertures and stop regions of the claimed “aperture layer” of the '405 patent.

2. *It would not have been obvious to combine Pacala and Droz*

110. Dr. Shanley asserts that it would have been obvious to combine the Pacala and Droz prior art references. Specifically, Dr. Shanley asserts that it would have been obvious to incorporate the waveguides of Droz into Pacala's spinning LIDAR system. EX1003 ¶¶126-28.

111. I disagree with Dr. Shanley that it would have been obvious to a POSITA to incorporate Droz's waveguides into Pacala's system. Dr. Shanley does not show how the waveguides of Droz would be incorporated into the Pacala system. Further, Dr. Shanley clearly does not know how the waveguides of Droz would be incorporated into a Pacala system. And it is clear from his testimony that incorporating the waveguides of Droz into the Pacala system would have required extensive experimentation on the part of a team of people.

112. Droz discloses that each of its waveguides is comprised of three types of layers, as shown in Figure 3B (reproduced below).

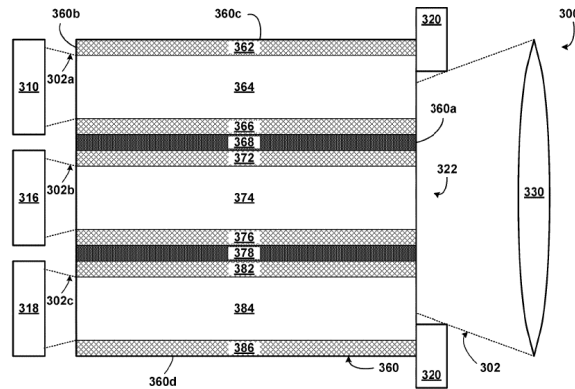


FIG. 3B

EX1006, Fig. 3B. First, the waveguides comprise “core layers” (elements **364**, **374**, and **384** in Figure 3B), which consist of a “relatively high index of refraction material, such as a glass or high-index polymer substrate for instance[.]” EX1006, 13:35-38. Second, the waveguides include “cladding layers” (elements **362**, **366**, **372**, **376**, **382**, and **386** in Figure 3B), which consist of “a relatively low index of refraction material, such as polymer coated or fluorine-doped glass substrates[.]” *Id.*, 13:31-34. Droz indicates that each waveguide has multiple cladding layers. *See id.*, Fig. 3B. Third, the waveguides include “[a]bsorbing layers,” comprised of a material that absorbs light like carbon black or black chrome. *See id.*, 13:39-43. Accordingly, the waveguides of Droz consist of “stacked” plates and layers, each of which consists of solid material. *Id.*, 4:29-39.

113. In the combination between Pacala and Droz, Dr. Shanley asserts that each pixel of photodetectors in the Pacala and Droz combination would have a waveguide. EX1003, ¶128. The Pacala reference discloses the use of eight photodetector channels. EX1004, Fig. 2. Accordingly, the combination between

Pacala and Droz would have at least eight core layers of stacked plates of glass or polymer, at least seven absorbing layers of carbon black or black chrome (between the core layers), and at least sixteen cladding layers made of polymer-coated or fluorine-doped glass (sandwiching the core layers). Further, Droz discloses implementations where cladding layers completely surround the core layers of the waveguides, leading to even more solid material being necessary to construct the waveguides. EX1006, 14:61-15:12.

114. Pacala discloses a spinning LIDAR system. EX1004 [0013] (disclosing “a static base **50** that contains a motor and distributed electronics, and a spinning turret **60** that contains optoelectronic components **70**”). In Dr. Shanley’s proposed combination of Pacala and Droz, the waveguides would spin. EX2011, 54:3-5 (“Q. So the waveguides in the Pacala-Droz combination would spin or rotate; is that correct? A. Yes.”)

115. Dr. Shanley provides only generalities about the Pacala-Droz combination. He fails to provide any analysis for how the Pacala-Droz combination would have been combined.

116. Dr. Shanley did not provide any analysis on how Droz’s waveguides could fit into the volume of Pacala’s system. Indeed, in his deposition, when asked how large the Pacala-Droz system combination would be, Dr. Shanley stated, “I really can’t answer that. I don’t know dimensions of objects and the system

requirements and things like that.” EX2011, 54:6-19.

117. Further, Dr. Shanley provides no analysis to indicate how a POSITA would have accounted for the weight of Droz’s waveguides in the combined Pacala-Droz system. Dr. Shanley did not even begin to do the kind of analysis necessary to determine the impact of Droz’s waveguides on the spinning Pacala system. Dr. Shanley testified that he could not say how much the combined Pacala-Droz system would weigh. EX2011, 54:6-13. Dr. Shanley further testified that he “couldn’t venture a guess” as to the mass distribution of the combined Pacala-Droz system. *Id.*, 54:20-55:4; *see also id.*, 56:21-57:2 (stating he “don’t have any of the data to do” the analysis necessary to calculate the mass distribution for the Pacala-Droz combination). Without analysis accounting for the impact of Droz’s waveguides on the weight of the combined Pacala-Droz system, Dr. Shanley’s obviousness opinions regarding the Pacala-Droz combination are unsupported.

118. Similarly, a POSITA would have understood that adding the stack of solid materials in Droz’s waveguides to the spinning Pacala system would have changed the gyroscopic forces acting on the spinning system. A POSITA would have understood that adding mass to a spinning device—particularly a stack of solid materials like Droz’s waveguides—will impact the rotational forces acting upon the device. This would have discouraged a POSITA from incorporating Droz’s waveguides into Pacala’s spinning system. Dr. Shanley testified that in a spinning

system, something can “go flying off” if the design is not adequate. EX2011, 61:2-11. However, Dr. Shanley provided no analysis to indicate how the design of the Pacala-Droz system would accommodate the gyroscopic forces caused by the introduction of the Droz waveguides into the spinning Pacala system. *Id.* (testifying that effective incorporation of the Droz waveguides into the Pacala system “depends on how good your design is”). Further, Dr. Shanley testified that he did not “know all the materials in the system” for the Pacala-Droz combination—making the issues discouraging the combination of these references particularly acute. *Id.*, 54:20-55:10.

119. Given the myriad design issues a POSITA would have faced in combining the Pacala and Droz references, a POSITA would not have found it obvious to combine these systems. Indeed, Dr. Shanley testified that he does not know if it would have taken a POSITA more or less than a man-year (which he defined as 2,000 hours) of work by a POSITA to combine the Pacala and Droz systems. EX2011, 60:2-19. Further, in Dr. Shanley’s view, a POSITA would not even have been a singular person. Rather, a POSITA would have been a *team* of engineers, including an optical engineer, an electrical engineer, and a mechanical engineer. *Id.*, 57:3-58:21 (“[Y]ou have to have a team to put all these pieces together.”)

120. Dr. Shanley further testified about the many steps required for a

POSITA team to combine the Pacala and Droz systems:

[U]sually the way these things are done is that there's a team of people, and there's the system guy who sets all the requirements, and he sort of runs the whole program. And then there's the optics guy saying, "Well, you've got to design optics for such-and-such a thing." And the electrical engineering guy says, "Okay, this is going to be my focal plane. This is going to be my laser. These are my electronic requirements." And then there's the mechanical guy, that says, "Okay, you guys, give me all that stuff and then I'll wrap my metal around it and design all the housing and stuff like that."

EX2011, 57:11-58:1.

I might caveat that also saying that when you start a system like this, you start looking at components and component availability and things. And I've been on systems where you required a detector array which wasn't off the shelf. And so you had to visit vendors and say, "Hey, I want a 1080-by-1024 array." And so it's not really quantifiable until you have a lot of information.

Id., 60:12-19.

121. I agree with Dr. Shanley that combining the Pacala and Droz systems would have been a complex and work-intensive operation that would have required a multidisciplinary team and thousands of hours of engineering time. As a result, it is my opinion that there would not have been a reasonable expectation of success for combining these systems. Based on the issues with combining Pacala's spinning LIDAR system with Droz's stack of solid waveguide layers—including volume,

weight distribution, and rotational forces—a POSITA would have been discouraged by the substantial amount of engineering work necessary to combine these systems. Accordingly, it is my opinion that it would not have been obvious to combine the Pacala and Droz systems.

B. Ground 2: Claims 24-25 and 32-33 over Pacala, Droz, and Villeneuve

122. My opinions regarding Dr. Shanley’s Ground 1 apply equally to Ground 2.

C. Ground 3: Claims 21 and 23-33 over Hall, Borowski, and Spector

123. Dr. Shanley asserts that claims 21 and 23-33 would have been obvious over Hall, Borowski, and Spector. I disagree with Dr. Shanley for the reasons provided below.

1. Hall and Spector are not combinable references

124. Dr. Shanley asserts that claims 21 and 23-33 are obvious over the combination of Hall, Borowski, and Spector. Specifically, Dr. Shanley asserts that it would have been obvious to incorporate the SPADs disclosed by Borowski into Hall’s spinning LIDAR system, and to incorporate Spector’s arrayed micro-optics at the light emission module of Hall and an aperture array from Spector at Hall’s light detection module. EX1003 ¶¶190-91. I disagree with Dr. Shanley that the Hall, Borowski, and Spector combo would have been obvious to a POSITA, because a POSITA would have recognized that Hall and Spector are not combinable

references.

125. Spector discloses a LIDAR system that detects distances to objects in a single scene—*i.e.*, the view of the external environment to the system from in a single direction. EX1005, 1:19-21 (defining a “scene” as “a contiguous portion of a physical space accessible to being viewed”); EX1010 at 13 (“To fill the scene, the illumination and detector aperture only have to be scanned the distance between illumination spots.”); *id.* at 18 (showing the scanning of a single direction under the title “Scanning the Scene”).

126. Spector’s system has a light source behind an array of microlenses, which causes a two-dimensional array of light spots to be projected onto the scene. EX1005, Fig. 9, 3:1-3; EX1010 at 12, 17-18. On the receiver side of Spector’s system, an aperture array is used to direct light from the illuminated points of the scene onto an array of detectors. EX1005, Fig. 1, 3:28-31, 3:38-42; EX1010 at 12, 17, 19. The detected points of the scene are shown in Figure 9 of Spector as the two-dimensional grid of black dots:

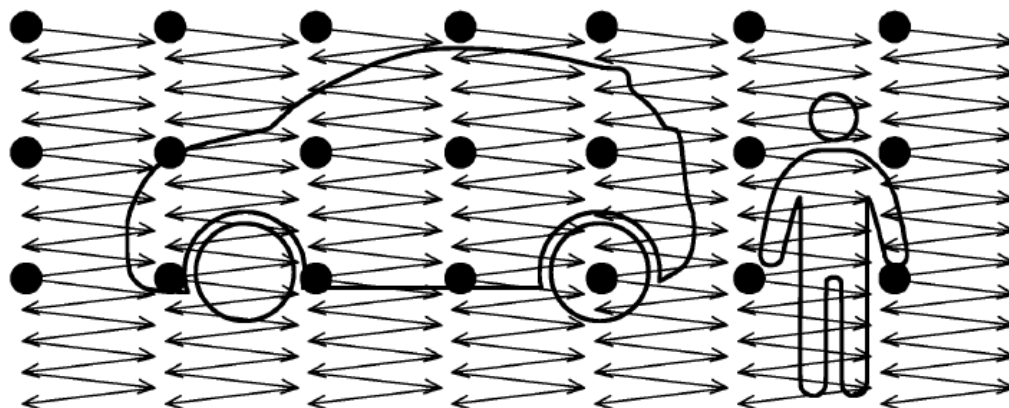
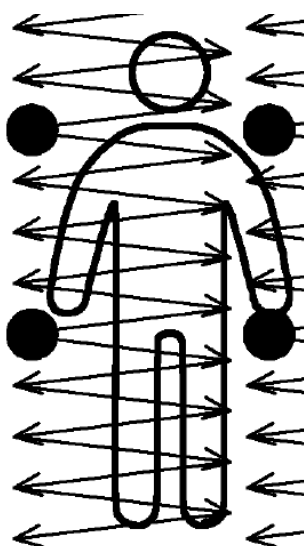


FIG. 9

EX1005, Fig. 9; EX1010 at 18.

127. Since the arrayed microlenses and aperture array cause only discrete points of the scene to be detected, they detect only a partial view of the scene. For example, as Figure 9 above demonstrates, the detected points of the scene (before any movement of those detected points, which I will discuss momentarily) completely miss the person standing in the scene:



EX1005, Fig. 9 (excerpt); EX1010 at 18. The black dots in the above image do not impinge on the person in the scene. Accordingly, this person is essentially invisible to the LIDAR system. If only these points of the scene were detected (with no horizontal and vertical scanning), then Spector's system would detect a very incomplete view of the scene.

128. To fill or complete the scene, Spector discloses mounting the microlens array and the aperture array on moving platforms that scan through the scene. EX1005, Figs. 1, 9; *id.*, 2:66-3:14, 3:62-65, 4:55-5:12; EX1010 at 12-13, 17-20.

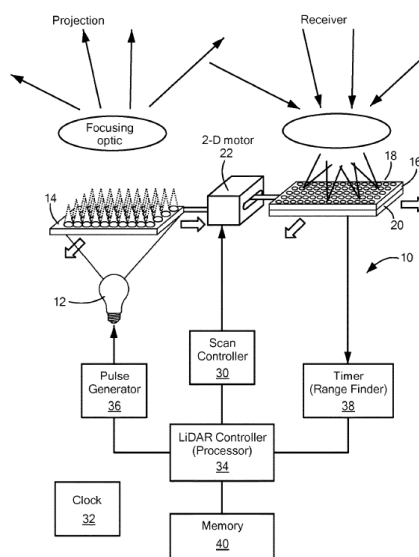
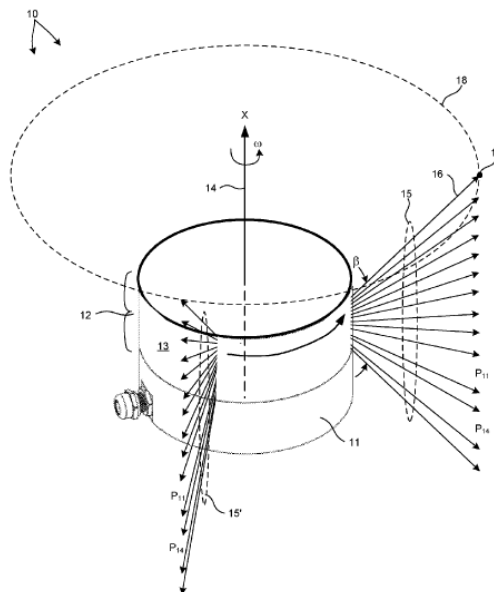


FIG. 1

EX1005, Fig.1; EX1010 at 19. Spector discloses scanning via back-and-forth motion less than the distance between the apertures. EX1005, 4:55-65; EX1010 at 13. This back-and-forth scanning motion can be seen in Figure 9 of Spector, reproduced above, in the chain of diagonal arrows extending from each of the dots. These arrows represent the motion of the projected light spots on the scene, caused

129. Unlike Spector’s system, which detects a single scene (*i.e.*, a view of an external environment from a single orientation) by scanning laterally up-and-down, Hall’s system rotates 360 degrees, as shown below in Figure 2:



EX1008, Fig. 2. Hall discloses that its system can rotate more than 200 revolutions per minute. *Id.*, 6:18-22. Dr. Shanley asserts that the combination of Hall,

Borowski, and Spector incorporates Borowski and Spector's features into the rotating LIDAR system of Hall. EX1003 ¶¶213-14.

130. Hall discloses that an important feature of a three-dimensional LIDAR system is the generation of a dense point cloud—*i.e.*, the set of environmental distance measurements generated through the operation of the LIDAR system that constitute its internal representation of its surroundings. EX1008, 11:21-25. Hall discloses that “imaging resolution depends on the density of the 3-D ‘point cloud’ generated by the LIDAR system.” *Id.*, 2:34-35. Hall further discloses that high levels of imaging resolution are desirable in a LIDAR system. *Id.*, 2:46-48. Hall indicates that “[a]ny alteration of the beam path, whether it is by mirror, prism, or actuation of the device that achieves a larger coverage area comes at a cost of decreased point cloud density.” *Id.*, 1:60-63.

131. It is my opinion that a POSITA would have considered the Hall and Spector systems to be fundamentally incompatible with each other. A POSITA would have understood that the use of micro-optic and aperture arrays in the Spector system requires the two-dimensional scanning motion disclosed by Spector to fill in the scene. A POSITA would not have understood that the micro-optic and aperture arrays could be isolated from the Spector system and used without a means for filling in the holes in the scene left by the discrete detection points. Further, a POSITA would have understood that a two-dimensional moving platform system like Spector

discloses would be incompatible with a rotating system, since the added rotational motion would prevent the two-dimensional scanning operation from filling in the scene. Neither Spector, Hall, nor Dr. Shanley's opinions about the knowledge of a POSITA provide any indication as to how a POSITA would have overcome the clear incompatibility of these systems. Accordingly, a POSITA would not have considered the Hall and Spector references to be combinable references.

132. A POSITA would have understood from Spector that using micro-optic and aperture arrays leaves significant gaps in a LIDAR system's detected area. For example, as discussed above, Spector shows that a LIDAR system could miss the presence of a *person* in a scene if micro-optic and aperture arrays are used in a LIDAR system without the horizontal and vertical scanning caused by Spector's moving platforms. EX1005, Fig. 9; EX1010 at 18. Moreover, a POSITA would have understood that the range data detected by using the micro-optic and aperture arrays of Spector would be of such a low resolution as to be useless—without the horizontal and vertical scanning motion caused by the moving platforms. For example, the following demonstrates the detection data a POSITA would have understood Spector's LIDAR system would have received for the above scene of a car and person—with red dots indicating closer objects and blue dots indicating further objects:

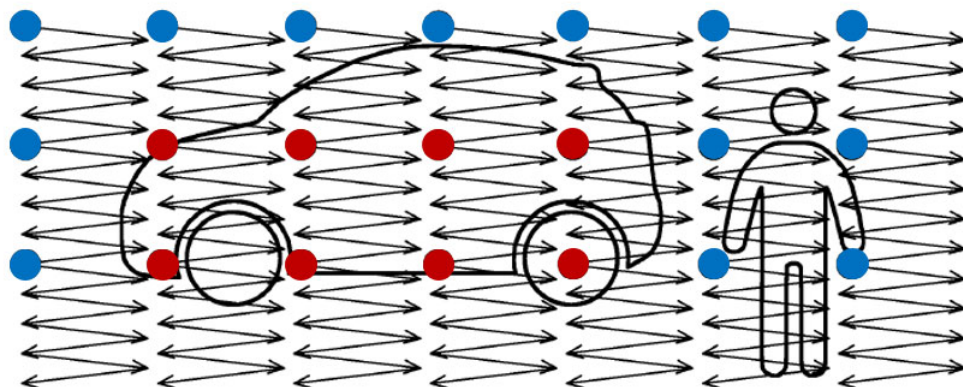
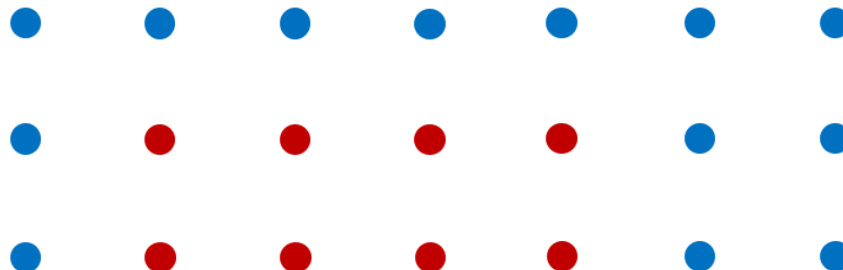


FIG. 9

EX1005, Fig. 9 (colored annotations added); EX1010 at 18. The below image—of just the detection data without the underlying scene—demonstrates the low resolution of Spector’s LIDAR system even more starkly:



There is *no* detection data related to the person in the scene. And the car detection data is nothing more than a rectangle, with significant details of the car not appearing at all—including its full length and height. EX1005, Fig. 9 (colored annotations added); EX1010 at 18.

133. Given the low detection resolution of the Spector system, a POSITA would have considered it to be crucial to use Spector’s micro-optic and aperture

arrays with a moving platform system that fills in the gaps—horizontal and vertical—left between the discrete detection points. A POSITA would have understood that the below image shows the detection data the Spector system would have received based on the scene of the car and the person by implementing a horizontal and vertical scanning system:

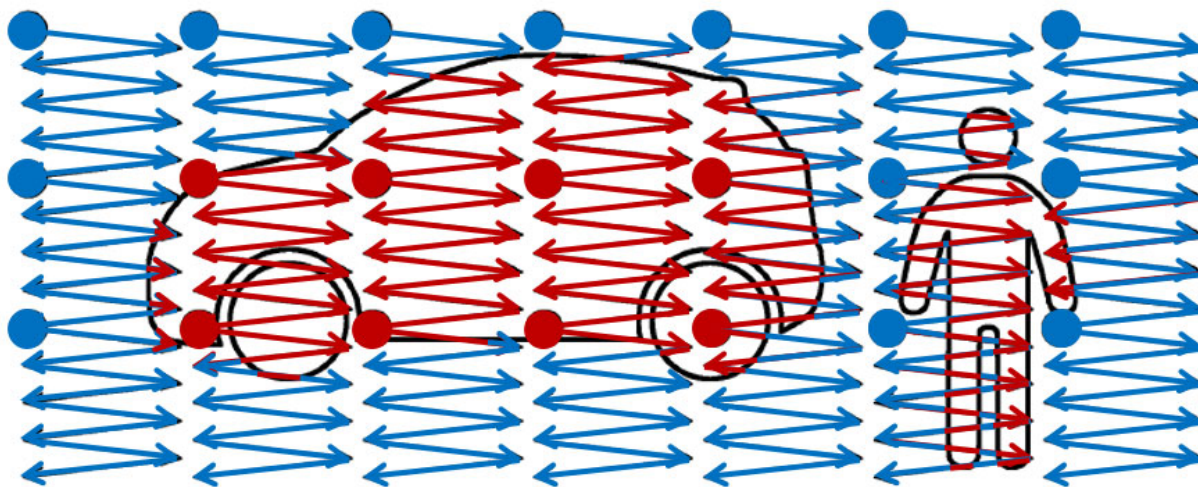
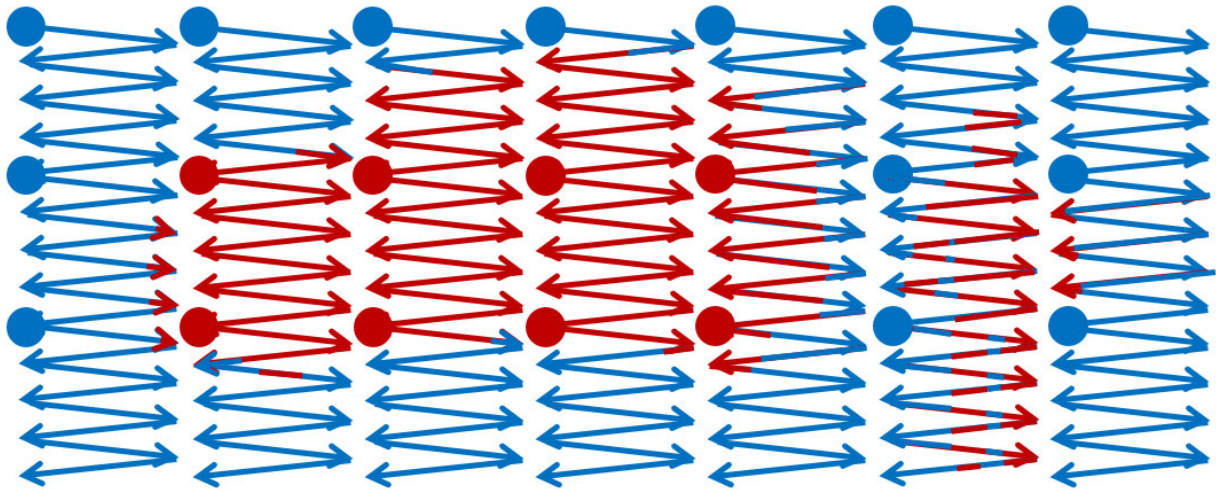


FIG. 9

EX1005, Fig. 9 (colored annotations added); EX1010 at 18. Removing the underlying scene from the above demonstrative shows the level of detail generated by Spector's system given the use of horizontal and vertical scanning:



The outline of the car and the person can be readily identified from the resulting detection data.

134. A POSITA would have understood the stark difference that horizontal and vertical scanning makes to the Spector system. Putting the detection data side-by-side generated (1) without and (2) with horizontal and vertical scanning shows the dramatic difference in image resolution for the Spector system:

<i>Without</i> horizontal and vertical scanning	<i>With</i> horizontal and vertical scanning

135. Given the difference in detection resolution of the Spector system with and without horizontal and vertical scanning, it would not have been obvious to a

POSITA to import the micro-optic and aperture arrays from Spector into the Hall system without also incorporating the moving platform system from Spector that vertically and horizontally scans the micro-optic and aperture arrays. A POSITA would have understood that without the moving platform system, the combination of Spector and Hall would lead to a poor detector with low resolution that leaves much of the environment undetected.

136. For example, a POSITA would have understood that by merely importing Spector's micro-optic and aperture arrays into the Hall system, the resulting detection image of the scene with a car and a person would look like the below—due to the horizontal scanning caused by the 360-rotation of the Hall system:

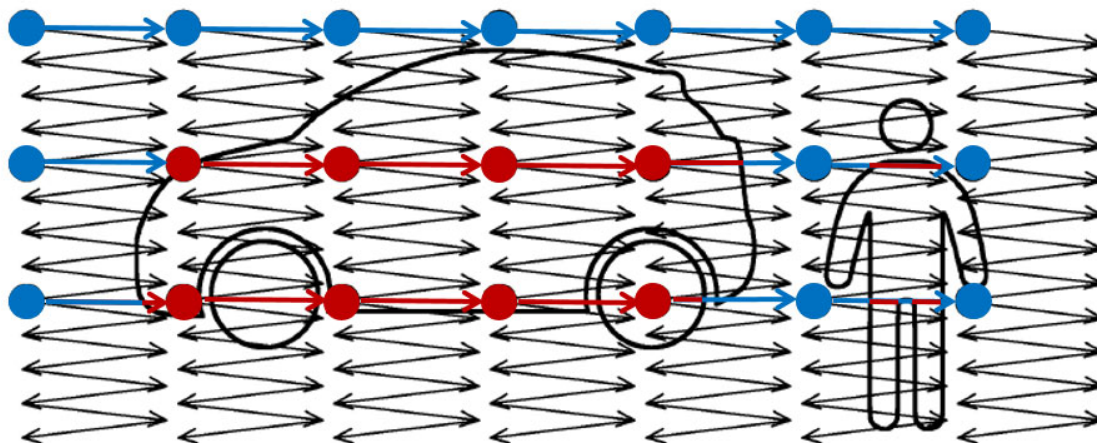
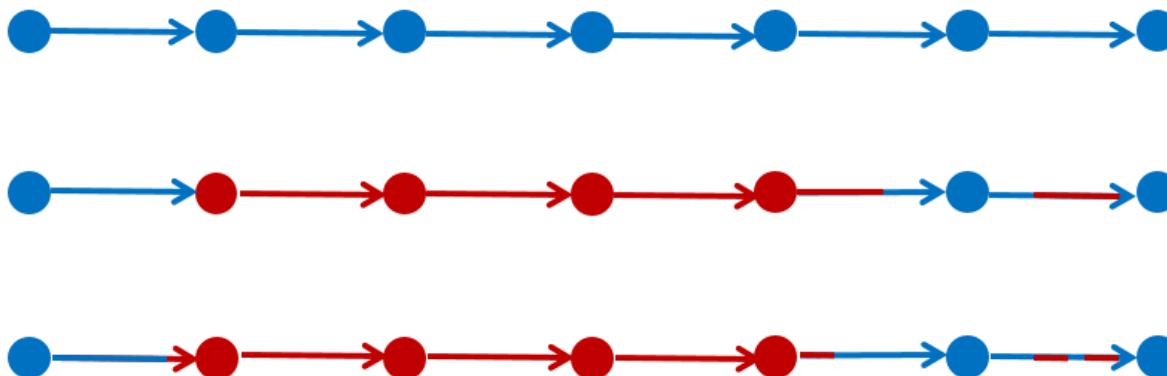


FIG. 9

EX1005, Fig. 9 (colored annotations added); EX1010 at 18. With the scene

removed, the detection data looks like the sparse image below—providing scant information about the scene:



Significant gaps appear between the detection regions, since there is no mechanism for filling in detection data for the vertical gaps between the points.

137. A POSITA would not have considered the low-resolution detector that would have resulted from the combination of Hall’s rotating system with Spector’s micro-optic and aperture arrays (without horizontal and vertical scanning) to be a viable LIDAR sensor. Hall explicitly discusses the importance of point cloud density and “maintaining sufficiently high levels of imaging resolution and range.” EX1008, 2:34-38, 2:46-48. Hall discusses example applications including mounting its system to a “vehicle operating on a roadway.” *Id.*, 3:3-4. But a POSITA would have recognized that the sensor resulting from the combination of Hall and Spector would have had woefully inadequate resolution and point cloud density—not even clear enough to detect a person in a scene or to identify a car or determine its full

length or height.

138. Furthermore, a POSITA would not have considered it viable to incorporate Spector's moving platform system into Hall's rotating LIDAR system. Spector's moving platform system is designed to scan detection points over a scene to fill in or complete a detected area of that scene. EX1005, 2:11-16 ("[T]he two dimensional array of light spots are scanned to complete a scan of the scene in such a manner that the spots traverse the scene in the first dimensional direction and in the second dimensional direction[.]" (emphasis added).) However, if Spector's moving platform system were incorporated into Hall's rotating LIDAR system, the device would be rotating at the same time that Spector's moving platform system was scanning. As a result, Spector's moving platform system could never complete a scan of a scene, because as it scanned, the scene would change due to the rotation of Hall's system. Accordingly, incorporating Spector's moving platform system into Hall's rotating LIDAR system would completely defeat the purpose of Spector's moving platform system.

139. A POSITA would further have understood that incorporating Spector's moving platform system into Hall's rotating LIDAR system would not have remedied the problem of low point cloud density and resolution. Indeed, the large gaps in the detected area of the combined Hall-Spector system shown in the demonstratives above would persist if the moving platform system were

incorporated. As discussed above, Spector's moving platform system would not be able to fill in the gaps between detection points, because the scene would change (due to rotation) before Spector's scanning system could fill in the gaps.

140. Dr. Shanley asserts that a POSITA would have been motivated to combine Hall with the micro-optic and aperture arrays of Spector to avoid cross-talk. EX1003 ¶191. Specifically, Dr. Shanley asserts that while Hall already proposes methods for avoiding cross-talk (staggering use of emitters, or only allowing emitters sufficiently spaced apart to emit light at the same time), Spector's micro-optics and apertures are a better way of avoiding cross-talk. *Id.* Dr. Shanley asserts that "Spector's implementation avoids the delays and spatial separation used by Hall, while still reducing cross-talk." *Id.*

141. I disagree with Dr. Shanley's analysis regarding motivations to combine the Hall and Spector systems. Regarding the motivation of avoiding Hall's spatial separation, the use of Spector's micro-optic and aperture arrays in Hall's system would not solve any spatial separation issues. Rather, spatial separation of the discrete detection points in Spector's system is precisely the issue that I discuss extensively above. Spector's discrete detection points are so spatially separated that Spector uses the moving platform system to fill in the gaps. But Dr. Shanley is not asserting that such a moving platform system would be incorporated into the Hall-Spector combination. And as I discuss above, a POSITA would have considered

Spector's moving platform system to be incompatible with Hall's rotating system.

142. Dr. Shanley's other motivation to combine relates to delay time. Hall discloses that one way to eliminate cross-talk in its system is to stagger the emission times of its emitters, such that one emitter—*e.g.*, emitter B—does not begin to emit light until another emitter—*e.g.*, emitter A—has stopped emitting light and the “time of flight of the measurement pulse sequence to and from an object located at the maximum range of the LIDAR device” has elapsed. EX1008, 9:13-16. In other words, to ensure that there is no cross-talk between emitters, one emitter waits the maximum time necessary to ensure that there is no light from a previously activated emitter that could reach the system. Dr. Shanley asserts that this process “limits the speed at which detection can be performed”—and Spector's implementation “avoids the delays.” EX1003, ¶191. However, such a consideration is clearly outweighed by the problems Spector's micro-optic and aperture arrays would have introduced into Hall's system. Using Spector's micro-optic and aperture arrays in Hall's system would mean that Hall's system *never* performs adequate detection, because it detects the environment at such a low resolution that substantial gaps are left in detection regions. Any motivation related to delayed detection is clearly outweighed by the issues with the Hall-Spector combination, since they relate to the ability of the system to detect the environment at all.

2. A POSITA would not have been motivated to use Spector's apertures with Borowski's SPAD arrays

143. Dr. Shanley asserts that it would have been obvious to combine Spector's aperture arrays with Borowski's SPAD arrays in the Hall-Borowski-Spector combination. (EX1003 ¶184.) I disagree with Dr. Shanley. A POSITA would not have been motivated to combine Spector's aperture arrays with Borowski's SPAD arrays.

144. Spector discloses the following regarding its aperture arrays:

For an optical sensor array in which the detectors are much smaller than the spacing between the detectors (fill factors less than 10%), such as in the Princeton Lightwave camera, the individual optical detection sites for correspondence with individual light spots are defined by the array itself. For detectors with a large fill factor, an aperture array may be beneficial to establish the individual optical detection sites.

(EX1005, 3:49-56.) As Spector indicates, a POSITA would have understood “fill factor” to refer to the ratio between the size of detectors in an array and the size of the spacing between detectors. Spector discloses that aperture arrays are *only* beneficial for detectors with a large fill factor. (*Id.*) For detectors with a small fill factor—*i.e.*, a fill factor below 10%—Spector discloses that its aperture arrays are unnecessary, because “the individual optical detection sites for correspondence with individual light spots are defined by the array itself.” (*Id.*)

145. In my opinion, a POSITA would have understood that SPAD arrays have a fill factor of less than 10%. For example, the article Sergey L. Vinogradov, “Evaluation of performance of silicon photomultipliers in LIDAR applications” (2017) discloses:

In contrast, a 2D SPAD array/matrix could be applicable for a photon number resolving detection and it is considered as potentially an ideal photon detector due to the ability to readout every photon count timestamp asynchronously and independently due to direct access to every single SPAD in the array. Regretfully, even mature CMOS technology does not resolve a problem of a low fill factor (ratio of sensitive area to the total area occupied by electronics for active quenching of Geiger discharge) of the front-side SPAD arrays. **For example, the recent development of MiSPIA (Microelectronic Single-Photon 3D Imaging Array) carried out by the world-recognized leaders in R&D of SPADs (Politecnico di Milano, Micro Photon Devices, Fraunhofer IMS) resulted in the fill factor of 3.14% for the 150 μm pitch 30 μm active area FrontSPAD array [20-21].**

(EX2014 at 3 (emphasis added).)

146. Vinogradov discloses attempts that have been made to increase the fill factor of SPADs using backside illuminated SPAD or digital SiPM technology. (*Id.*, 3-4.) But Vinogradov discloses that each of these attempted approaches introduces significant issues:

Regretfully, an attempt to eliminate the fill-factor problem by using backside illuminated SPAD technology with SOI substrate introduced prohibitively high dark count rate (DCR) of about 240 Kcps for a single pixel of the 150 μm pitch 143 μm active area BackSPAD array with the fill factor of 71.4% (about 40 times higher than DCR for the FrontSPAD. The better result (fill factor of 20% for the front-side SPAD array of 4x32 SPADs – so-called digital SiPM, dSiPM) has been reported by partially the same team (Politecnico di Milano, Micro Photon Devices) a year later [22].

Another approach to a SPAD array design has been demonstrated by Philips in their digital SiPM (dSiPM), where a direct access is provided to a sub-group of SPADs (sub-pixels of dSiPM) to reduce the number of electronic components and connections at the front-side area [23]. The fill factor of the dSiPM initially was achieved at the level of 50% (pixel size of 52 μm $\times$ 30 μm), i.e. about comparable with conventional analog SiPMs which fill factor is in a range of 30% - 80% depending on a pixel size. In the recent optimization of the dSiPM, the fill factor has been improved to 78% (pixel size of 59.4 μm x 64 μm) [24]. However, dSiPM technology is rather expensive and inflexible in scaling of the dSiPM dimensions and especially in producing arrays of dSiPMs due to large periphery occupied by electronics.

(*Id.* at 3-4 (emphasis added).)

147. Given the low fill factor of SPAD arrays and the problems attending any attempts to increase the fill factor, Vinogradov discloses:

Therefore, to the best of the author's knowledge, there are no attempts either to implement SPAD arrays or dSiPMs as a single photon number resolving LIDAR receiver or to combine an array of SPAD arrays or dSiPMs as a focal plane array of photon number resolving detectors in 3D imaging LIDARs. In this situation, detailed analysis of the SPAD-based receivers is out of the scope of this paper.

(*Id.* at 4.) Vinogradov confirms that a POSITA would not have considered there to be a reasonable expectation of success for increasing the fill factor of SPAD arrays.

148. Since a POSITA would have considered SPAD arrays to have a low fill factor below 10%, and since a POSITA would not have considered there to be a reasonable expectation of success for increasing the fill factor of SPAD arrays, it is my opinion that a POSITA would not have been motivated to combine Spector's apertures (which are only beneficial for detectors with a high fill factor) with Borowski's low fill factor SPAD arrays.

3. Borowski's noise-prone SPADs are not combinable with Hall's noisy LIDAR system

149. Dr. Shanley asserts that it would have been obvious to combine Hall with Borowski by using SPAD arrays from Borowski as the photodetectors in the Hall system. EX1003 ¶184. For the reasons provided below, I disagree with Dr. Shanley that it would have been obvious for a POSITA to incorporate Borowski's SPAD arrays into Hall's system.

150. The sole detector disclosed by Hall for use in its LIDAR system is an avalanche photodiode or APD. Hall incorporates by reference U.S. Patent No. 7,969,558 (“Hall ’558”), which shares its named inventor—David S. Hall—with the Hall reference Dr. Shanley relies on for his Grounds 3 and 4. EX1008, 2:10-14. Hall discloses that Hall ’558 discloses “a LIDAR system . . . that includes an array of multiple laser emitters and detectors.” *Id.*, 2:9-11. Hall ’558 discloses that the detectors are APDs. EX2012 (Hall ’558), 5:27-31 (“[T]he detection circuitry consists of high speed A-D’s[.]”), 5:6-7 (“[T]he photo diode is preferably an Avalanche variety, but other types can be used.”) Hall generally discloses that undisclosed “other types” of photodiodes can be used. *Id.*, 5:6-7. But Hall never mentions any kind of photodetector other than APDs. And Hall is clear that APDs are “preferably” the type of photodiode used in its system. *Id.* Accordingly, a POSITA would have understood that Hall should be used with APDs or photodetectors that function similarly to APDs.

151. Dr. Shanley’s combination of Hall and Borowski replaces the disclosed APDs in Hall’s system with SPAD arrays disclosed by Borowski. EX1003 ¶186. Dr. Shanley provides no discussion of why it would have been obvious to a POSITA to make this replacement in the Hall system. Rather, Dr. Shanley completely ignores the disclosure of APDs in the Hall system—instead suggesting that Hall only discloses generic “light detecting elements.” *Id.* ¶187. As a result, Dr. Shanley

focuses only on why it would have been obvious to use Borowski's SPAD arrays in the Hall system—not why it would have been obvious to *replace* Hall's disclosed APDs with Borowski's SPAD arrays. *Id.* ¶¶184-87. Therefore, Dr. Shanley's analysis is simply missing essential analysis on the obviousness of the combination of Hall and Borowski and the motivation to combine these references. By opining on the alleged obviousness of SPAD arrays in the abstract, and not as a *replacement* for Hall's APDs, Dr. Shanley has provided a solution without showing that there is a problem to be solved. Hall already discloses detectors—APDs—so there is no reason a POSITA would have looked to another type of detector—SPAD arrays—unless there was a reason to replace APDs with SPAD arrays in the Hall system. Dr. Shanley fails to provide that reason. In fact, he fails to acknowledge that APDs are disclosed for the Hall system at all. Accordingly, Dr. Shanley fails to show the obviousness of the Hall-Borowski combination.

152. Further, it would not have been obvious to a POSITA to replace Hall's APDs with Borowski's SPAD arrays. A POSITA would have understood that Borowski's SPAD arrays would have been significantly more prone to noise than Hall's APDs. Accordingly, a POSITA would not have considered Borowski's SPAD arrays to be combinable with Hall's system, which includes significant sources of noise.

153. Hall discloses that in LIDAR systems, “[t]he detection of return signals

includes significant sources of measurement noise that are exacerbated as measurement ranges are extended.” EX1008, 2:29-31. Indeed, Hall discloses applications for its LIDAR system in noisy environments. For instance, Hall discloses using its LIDAR system in an autonomous vehicle—which a POSITA would have recognized as involving ample noise like competing light sources and temperature fluctuations. *Id.*, 1:64-2:14. Further, Hall discloses that such an application requires “see[ing] over a broad field of view”—exposing the system to further noise sources. *Id.*, 1:65-66.

154. A POSITA would have understood that SPADs are much more prone to noise than APDs. A POSITA would have understood that SPADs are more sensitive to light than APDs. This difference in sensitivity can be seen in the names of the respective detectors. APDs are avalanche photodiodes—whereas SPADs are single-photon avalanche diodes. Unlike an APD, a SPAD is so sensitive that it can detect a single photon. Dr. Shanley appears to agree with this understanding. He provides opinions indicating that the high gain of SPADs means that they can detect very small amounts of light—much smaller than what APDs are capable of detecting. EX1003 ¶¶45-49.

155. A POSITA would have understood that the sensitivity of SPADs comes with problems. For example, a POSITA would have understood that SPADs are far more prone to noise than APDs. In part, this is intuitive. Since SPADs can detect

light at lower intensities than APDs, SPADs detect light from significantly more sources—whether those sources are relevant to the LIDAR system (*e.g.*, light pulses from the system’s emitters) or irrelevant information (*e.g.*, ambient light). Dr. Shanley mentions SPADs’ “particularly problematic” potential for noise and interference. EX1003 ¶50.

156. But a POSITA would have understood that the proneness of SPADs to noise does not stop with greater sensitivity to ambient light. A POSITA would have also understood that the sensitivity of SPADs makes them prone to noise in the form of various types of spurious detection. For example, the 2013 article Edoardo Charbon et al, “SPAD-Based Sensors” provides an extensive list of noise sources for SPADs:

Photons are not the only source of initial carriers; uncorrelated or correlated noise can also cause free carrier injection and undesirable avalanches. Uncorrelated noise sources include: ambient light; tunneling from an electric field that is too high; and fabrication defects which ease valence-to-conduction band transitions, such as thermally generated or tunneling carriers. The last factor, fabrication defects, can also cause afterpulsing, a type of time-correlated noise. Traps in the forbidden energy band can fill, only to release free carriers on the time scale of tens of nanoseconds following an avalanche. Afterpulsing prevents an instant recharge phase in SPADs, and places constraints on the minimum dead time.

There are other sources of correlated noise besides afterpulsing—optical and electrical crosstalk are the most common, but in practice afterpulsing is the dominant type of correlated noise.

EX2015 at 14.

157. Further, the 2006 article Cristiano Niclass, et al, “A Single Photon Avalanche Diode Array Fabricated in Deep-Submicron CMOS Technology” states:

Thermally or tunneling generated carriers within the p-n junction, which produce dark current in linear mode photodiodes, can trigger avalanche pulses. In Geiger mode, they are indistinguishable from regular photon-triggered pulses and they produce spurious pulses at a frequency known as *dark count rate* (DCR). DCR strongly depends on temperature and it is an important parameter for imagers since it defines the minimal detectable signal, thus limiting from below the dynamic range of the imager. Another source of spurious counts is represented by after-pulses. They are due to carriers temporarily trapped during a Geiger pulse in the multiplication region that are released after a short time interval, thus re-triggering a Geiger event. After-pulses depend on the trap concentration as well as on the number of carriers generated during a Geiger pulse.

...

During an avalanche, some photons can be emitted due to the electroluminescence effect [21]. These photons may be detected by neighboring pixels in an array of SPADs thus producing crosstalk. The probability of this effect is called optical crosstalk probability.

. . . Electrical crosstalk on the other hand is produced by the fact that photons absorbed beyond the p-n junction, deep in the substrate, generate carriers that can diffuse to neighboring pixels. The probability of occurrence of this effect, whether it is optical or electrical, defines the *crosstalk probability*.

EX2016 at 2-3.

158. Since a POSITA would have understood that SPADs are particularly sensitive to noise, including as compared to Hall's APDs, a POSITA would have understood that Borowski's SPAD arrays would not have been combinable with Hall's system, which contains "significant sources of measurement noise." EX1008, 2:29:31, 1:64-2:14. Indeed, Dr. Shanley provides no analysis on how Borowski's noise-prone SPADs could be incorporated into a high-noise system like Hall's. Further, Dr. Shanley makes clear that the *only* feature of Borowski he is importing into Hall's system is Borowski's SPAD arrays. EX1003, ¶¶184. Therefore, Dr. Shanley provides no analysis to suggest that Borowski provides teachings for handling the noise-prone nature of SPADs in Hall's system. And Hall clearly does not provide any teachings to suggest how to accommodate noise-prone SPADs into its system. Hall discloses using APDs—and it never mentions SPADs. EX2012 (Hall '558), 5:28-31. In other words, Dr. Shanley appears to have simply bolted SPADs on to Hall's noisy, APD-based system and hoped for the best—despite the fact that a POSITA would have known (based on Dr. Shanley's own analysis) that

noise and interference was “particularly problematic” in SPAD-based systems. EX1003 ¶50.

159. Accommodating the noise characteristics of SPADs in a spinning LIDAR system like Hall discloses would not have been within the knowledge of a POSITA. Dr. Shanley provides high-level statements about techniques related to noise in the abstract. EX1003, ¶¶51-56. But he provides no opinions as to which, if any, of these techniques would be suitable or sufficient to address noise for SPADs in the context of Hall’s spinning LIDAR system. Further, Dr. Shanley only identifies techniques related to stray light noise and certain cross-talk. *Id.* But as I discussed above, a POSITA would have known about a wide range of noise sources that would need to be addressed for SPADs *other* than stray light—*e.g.*, thermal noise, electroluminescence, electrical cross-talk, optical cross-talk, tunneling, and afterpulsing.

D. Ground 4: Claim 34 over Hall, Borowski, Spector, and Droz

160. My opinions regarding Dr. Shanley’s Ground 3 apply equally to Ground 4.

VIII. SECONDARY CONSIDERATIONS

161. I understand that there are certain secondary considerations of nonobviousness that are relevant to the determination of invalidity based on obviousness over the prior art. I provide my opinions as to these secondary

considerations below.

A. Skepticism

162. I understand that industry skepticism is a secondary consideration of nonobviousness.

163. It is my opinion that there was significant industry skepticism about the use of SPADs in a LIDAR device prior to the '405 patent.

164. Such industry skepticism is supported, for instance, by Dr. Shanley's testimony. Dr. Shanley testified that he could not identify a single LIDAR system—commercial or noncommercial—that used SPADs prior to the '405 patent. EX2011, 77:1-8, 79:2-80:16.

165. Further, Dr. Shanley testified that while he was aware of SPADs as of the 1990s, he never incorporated them into a system he worked on, including any of the LIDAR systems he worked on. EX2011, 12:18-22, 14:13-15:5.

166. Dr. Shanley additionally testified that in at least one instance, he specifically recalls choosing to use photodiodes as the photodetectors of a LIDAR system instead of SPADs. EX2011, 16:20-17:1. Dr. Shanley testified that his team did not use SPADs in the system because “[w]e didn’t have the volume and the power required at that point, and we wanted a simple system.” *Id.*, 17:2-5. Further, Dr. Shanley testified that his team needed something that, unlike SPADs, was “very simple” and “very fast and very quick and very reliable.” *Id.*, 18:10-15. Since

photodiodes were “cheap” and an “off-the-shelf array,” Dr. Shanley’s team decided to use photodiodes in the system rather than SPADs. *Id.*, 17:6-12.

167. Further, Dr. Shanley testified that he could not identify any LIDAR system sold prior to the ’405 patent that used SPADs. EX2011, 77:1-8. While Dr. Shanley suggested that there were noncommercial uses of SPADs in LIDAR systems prior to the ’405 patent, when questioned on specifics, he made it clear that this was based solely on assumptions and his “gut feeling” based on trends in the last three or four years (long after the ’405 patent’s priority date):

Q. Dr. Shanley, you mentioned that you weren't aware of any commercial LiDAR devices that use SPADs prior to the ’405 patent; is that correct?

A. Yes.

MR. HAGIZ: Objection to form.

Q. But you indicated that there were possibly some noncommercial LiDAR devices prior to the ’405 patent that use SPADs; is that correct?

A. Yes.

Q. So what were those devices?

A. I would assume that a lot of people doing the geophysical imaging and NASA programs and things like that have gravitated to using SPADs.

Q. So you said you assume that those systems use SPADs?

A. I would think so.

Q. What's your basis for thinking that?

A. They're more sensitive detectors. And I might say also, the commercial availability of the arrays -- because Sony and Osram and a whole bunch of people are now supplying SPADs, SPAD arrays.

Q. And you say now supplying SPAD arrays, Sony, Osram. I mean, do you know how long they've been providing SPAD arrays?

A. I would assume over the last three or four years, though I don't know that's true. We could go back and compile a history. But it's just my gut feeling that that technology has really matured to be cheap and off-the-shelf -- though prior to that people probably -- You know, if I needed a SPAD array and it wasn't available, I would go directly to the manufacturer and fund a program to actually build me these detectors for a specific application.

Q. So can you name a specific system prior to the '405 patent that used SPADs in a LiDAR system?

A. Not at this point.

EX2011, 79:2-80:16.

B. Failure of Others

168. Prior to the '405 patent, the literature is replete with discussion of failures to use SPADs in LIDAR systems. For example, an article right around the May 15, 2017 priority date of the '405 patent discloses repeated failures to develop

practicable SPAD arrays. The article Sergey L. Vinogradov, “Evaluation of performance of silicon photomultipliers in LIDAR applications” discloses:

2D SPAD array/matrix could be applicable for a photon number resolving detection and it is considered as potentially an ideal photon detector due to the ability to readout every photon count timestamp asynchronously and independently due to direct access to every single SPAD in the array. **Regretfully, even mature CMOS technology does not resolve a problem of a low fill factor (ratio of sensitive area to the total area occupied by electronics for active quenching of Geiger discharge) of the front-side SPAD arrays.** For example, the recent development of MiSPIA (Microelectronic Single-Photon 3D Imaging Array) carried out by the world-recognized leaders in R&D of SPADs (Politecnico di Milano, Micro Photon Devices, Fraunhofer IMS) resulted in the fill factor of 3.14% for the 150 μm pitch 30 μm active area FrontSPAD array [20-21]. **Regretfully, an attempt to eliminate the fill-factor problem by using backside illuminated SPAD technology with SOI substrate introduced prohibitively high dark count rate (DCR) of about 240 Kcps for a single pixel of the 150 μm pitch 143 μm active area BackSPAD array with the fill factor of 71.4% (about 40 times higher than DCR for the FrontSPAD.** The better result (fill factor of 20% for the front-side SPAD array of 4x32 SPADs – so-called digital SiPM, dSiPM) has been reported by partially the same team (Politecnico di Milano, Micro Photon Devices) a year later [22].

Another approach to a SPAD array design has been demonstrated by Philips in their digital SiPM (dSiPM), where a direct access is provided to a sub-group of SPADs (sub-pixels of dSiPM) to reduce the number of electronic components and connections at the front-side area [23]. The fill factor of the dSiPM initially was achieved at the level of 50% (pixel size of $52\text{ }\mu\text{m} \times 30\text{ }\mu\text{m}$), i.e. about comparable with conventional analog SiPMs which fill factor is in a range of 30% - 80% depending on a pixel size. In the recent optimization of the dSiPM, the fill factor has been improved to 78% (pixel size of $59.4\mu\text{m} \times 64\mu\text{m}$) [24]. **However, dSiPM technology is rather expensive and inflexible in scaling of the dSiPM dimensions and especially in producing arrays of dSiPMs due to large periphery occupied by electronics.** **Therefore, to the best of the author's knowledge, there are no attempts either to implement SPAD arrays or dSiPMs as a single photon number resolving LIDAR receiver or to combine an array of SPAD arrays or dSiPMs as a focal plane array of photon number resolving detectors in 3D imaging LIDARs.** In this situation, detailed analysis of the SPAD-based receivers is out of the scope of this paper.

EX2014 at 2-3 (emphasis added).

169. Dr. Shanley himself testified to the necessity of using ample supporting circuitry for SPADs like quenching circuits. Dr. Shanley testified that without such circuitry (which the Vinogradov indicates was a highly limiting factor in the use of SPAD arrays prior to the '405 patent), he has seen SPAD-based systems fail

dramatically:

Q. So what happens with SPADs if you don't have a quenching circuit?

A. Okay, I have a lot of experience with that. Initially –

So you have this IV characteristic; okay? And if you start biasing here and you continue biasing –

So what you have is current and voltage characteristic here, and this is voltage here, and this is current on this axis.

So if you continue biasing -- and what happens is, when you operate down here, it's going to automatically increase to go to infinity. So what happens is this whips back to zero, and you may burn your diode out. You may just destroy it. I've seen things where they actually go into thermal runaway and all you have is a heated mess of semiconductor there. I've done many of those.

EX2011, 70:5-22.

170. Since the challenged claims all require photosensors made up of a plurality of SPADs, the repeated failure of others to develop SPAD arrays that could be used in a LIDAR system indicates that the challenged claims are not obvious over the prior art. *See, e.g.*, EX1001, claims 21, 26.

IX. RESERVATION OF RIGHTS

171. The opinions and analyses in this report are based on currently available documents and information. Accordingly, I reserve my right to supplement and amend my opinions if additional information becomes available. Similarly, this

report may be supplemented by testimony.

172. I also reserve the right to adjust or supplement my analyses in light of any rebuttal or alternative opinion advanced by the Petitioner.

X. CONCLUSION

173. In my opinion, claims 21 and 23-34 of the '405 patent are not invalid in light of the prior art grounds asserted by Dr. Shanley.

Dated: June 25, 2024

Respectfully submitted,

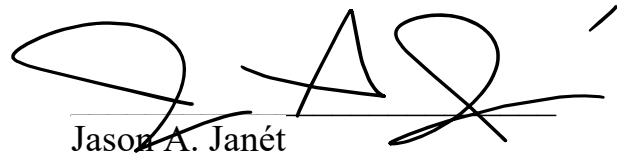
A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke extending to the right.

Jason A. Janét

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Dated: July 12, 2024

Respectfully submitted,



Jason A. Janét

EXHIBIT A

Jason A. Janét, Ph.D.

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Education

- Ph.D. Electrical & Computer Engineering, North Carolina State University, 1998
- M.S. Integrated Manufacturing Systems Engineering, North Carolina State University, 1994
- B.S. Mechanical Engineering, University of Virginia, 1990

Employment History

Applied Research Associates (ARA): 2018 - present

- **Corporate Director of IP and Product Commercialization (IP to Product—IP2P) | CTO-SSM:** Corporate/Business development, Intellectual Property Portfolio Build-out/Protection, and IP Transition to Product. Evaluate, quantify, present and recommend portfolios of IP, product lines and ventures on the basis of competitive landscapes, addressable markets, sales strategy, resource availability and technology readiness. Design, propose and mentor organizational structure(s), including cross-department and cross-sector relationships. Relevant technologies include medical technologies, augmented reality, non-GPS, synthetic environments, computer vision, machine intelligence, IoT sensors, robotics, automation, security, photogrammetry, weapons systems, unmanned systems, SaaS, BioTech, and precision agriculture for multiple market domains. Clearance Level: TOP SECRET & SCI.

DeltaFive: 2014 - 2018

- **CEO & Co-Founder:** Lead corporate, business, IP and technical development for spinout focused on IoT sensors, computer vision, machine intelligence, mobile robots, SaaS, and Lure Formulation for hospitality, pest, IT, and security markets. Strategic and tactical direction for sales, marketing and client services teams.
- **Inventor:** Three awarded patents (USPTO) and patents pending.
- **Board of Directors:** Serve on and report to Board of Directors, and chair the Technical Advisory Board.
- See www.deltafive.com, <https://jgc.outgrow.us/deltafive> or www.youtube.com/watch?v=LoQe6_Lxprs.

Transdigm [TDG] (Avionic Instruments | Acme Aerospace | Aerospace Cooling Solutions): 2002 – 2004, 2013 - 2014

- **VP/Director of Development (2002-2004), VP/Director of Sales, Program Management (2013-2014).** See www.transdigm.com, www.avionicinstruments.com, www.acme-aero.com, or www.aerospacecoolingsolutions.com.
 - Manage multiple product lines and cross-functional teams including product line managers (PLMs), account managers, inside sales, international sales, marketing, repair, engineers, technicians, distributors, legal, IP and rep organizations. (270 employees)
 - P&L, strategy, reporting, and forecasting for ~\$105M/yr, 50% EBITDA, and 10% YOY growth.
 - Product lines comprised ~600 SKUs for advanced aerospace systems.
 - Epicor ERP for standard resource planning, including inventory optimization and workflow.
 - Change-Agent: Sikorsky S97/JMR programs and supply chain for Aerospace Cooling Solutions.
 - Incubation, launch, growth and exits for **ShelfWorks**, **VortexHC** and **RxMedic** (below).
- **Programs:**
 - **S97 Raider Light Tactical Helicopter** – Autonomy, power distribution and electrical system (PDES) for the Sikorsky S97 LTH, including FAA-compliant software development per DO-178B. (2013 – 2014) See <http://www.youtube.com/watch?v=qy-Xb3X-bC0>.
 - **Joint Multi-Role (JMR) Helicopter** – Leveraging S97, JMR employs a scaled-up level of autonomy/PDES for Sikorsky-Boeing team, under U.S. Army funding. (2014)
 - **Blue Fans** – Aerospace Cooling Solutions supply chain optimization. (2013 – 2014)
 - **DARPA Distributed Micro-Robotics** – PI/PM for “Mobile Robots that Climb Vertical and Inverted Surfaces.” sponsored by DARPA – MTO. Develop mobile robots that climb walls and ceilings for surveillance, reconnaissance and breaching. Collaborated with Lockheed-Martin for automatic target recognition and Picatinny Arsenal for *Lamprey* SLAM holder. (2002 – 2004)

Teledyne Technologies [TDY]: 2011 - 2013

- **Senior Manager**

- Lead cross-functional teams of scientists and engineers in CONUS
- M&A due-diligence, identification and recommendation (SeaBotix & BlueView)
- Lead contingents of cross-division teams to secure ~\$352M in funding over 24 months.
- Plan and execute CRAD, business development and coordinate with strategic business units
- **ONR/USMC Cargo UGV** – PM for ONR/USMC-sponsored Cargo Unmanned Ground Vehicle (CUGV) Program subcontract (2011-2012). Manage team of engineers and scientists, in coordination with contract prime (Oshkosh) for unmanned combat vehicle control, perception and navigation. Multi-sensor suite included EO/IR Vision, LIDAR, IMU, and GPS.
- **Army LTL** – PM for Army-sponsored Lighten-the-Load (LTL) Program subcontract (2012-2013). Manage team to develop perception system comprised of stereo EO and stereo LWIR cameras to find and track leader(s), perform optical odometry, detect and map obstacles, and enhance SIGINT. Interface with sensors (LIDAR, IMU, GPS), autonomy for ATV-sized unmanned ground vehicles.
- **NASA ESP** – PM for RTP-based tasks for NASA Engineering Services and Prototyping demonstration (2012-2013). Provide Teledyne Engineering Services (lead), SAIC, Oceaneering, and Schafer with robot prototype and vision-based perception to detect, classify and track targets.
- **DARPA EXACTO** – PM for NC-based tasks for DARPA TTO Extreme Accuracy Tasked Ordnance (EXACTO) Program (2012-2013). Program developed first ever guided, small-caliber bullet with MEMS-based actuation, optical bullet tracking, optical target tracking, and bullet guidance to greatly improve accuracy and extend the day and nighttime range over current state-of-the-art sniper systems.
- **DARPA AngelFish/EagleRay** – PI/PM and inventor of the AngelFish Cross-Domain Submersible UAV, a man-portable, floodable airframe with tilt-thrusters capable of operating in and deliberately transitioning between the air, surface and underwater. Designed for optimal balance between hydro-/fluid-dynamics, materials, guidance/navigation/control, power conversion/storage, and perception for wing-in-ground flight.
- **Army PIRST** – Propose and capture the Pursuant In-stride Reconnaissance, Surveillance & Targeting (PIRST) program. By Army Night Vision & Electronics Sensors Directorate (NVESD) in 2013.

RxMedic Systems: 2003 – 2011 (*spinout from Avionic Instruments*)

- **Co-Founder/General Manager/Board Member** (2004-2007), **CTO** (2007-2010), and **Director of Robotic/Automated Systems** post-acquisition by JM Smith (2010-2011).
 - Manage launch from **Avionic Instruments** (2004)
 - Build and lead nationwide growth of cross-functional teams to 75+ employees
 - Direct product development, manufacturing, field support, sales and marketing
 - Manage IP Portfolio & Legal: Patents include USPTO# 7,726,514 and 8,091,733
 - Oversee P&L, accounting, raising of capital, and accounts receivable
- **RxMedic ADS:** Invent, develop, market and support automated pharmacy dispensation and packaging systems for retail, hospital, mail order and industrial fulfillment organizations.
- **RxMedic ACS:** Integrate, refine, market and support automated pharmacy-counting systems for retail and hospital fulfillment organizations.
- Co-negotiated the acquisition of RxMedic Systems by JM Smith, Inc. in May of 2010, established RxMedic as a division, and coordinated 12-month transition. Supported evaluation and integration of automated systems for JM Smith business units including Smith Drug.

Vortex HC: 2002 - 2009 (*spinout from Avionic Instruments*)

- **Vice President** (2004-2006), and **Facilities Security Officer (FSO)** (2005-2006)
 - Manage spin-out from **Avionic Instruments** (2004)
 - Lead cross-functional teams for product development, manufacturing, support, sales and marketing
 - Manage business and corporate strategy, execution, licensing, and ITAR/EAR-compliance
 - Support domestic and international legal and IP portfolio management, P&L, AP/AR
- **DARPA ARTEMIS** – PI and PM for “Vortex-Based AUVs for Counter-Mine and Counter-Obstacle Operations” sponsored by DARPA – ATO. Managed development of holonomic AUVs for landing on mines and performing soft-kill neutralization. Integrated CFD, rugged materials, MEMS-sensors for guidance, navigation and control. Collaborated with UT-ARL for development of circular synthetic aperture sonar and Teledyne RD Instruments for DVL. Developed high-precision acoustic underwater tracking system.
- **Products:** Managed development, manufacturing, world-wide marketing, and support of the following to military, law-enforcement, security, rescue, nuclear and entertainment customers:
 - VMRP Wall-Climbing Robot – Man-portable mobile robots that climb walls and ceilings.
 - Submersible Attractor – Rad-hardened attractor for nuclear energy market, BWR inspection
 - Submersible VMRP Robot – Man-portable underwater robots for bulkheads and tank interiors.

- Lamprey SLAM Holder – Surface-agnostic instant placement mechanism for Picatinny Arsenal’s Selectable Land- and Anti-personnel Mine (SLAM) breaching charge.
- **Licensing:** As part of exit strategy, instituted licensing and transition of VRAM technologies:
 - SeaBotix LBC – Little Benthic Crawler Remotely Operated Vehicle (ROV).
 - SeaRobotics HullBUG – Autonomous hull-grooming robot.
 - BDT – Attractors for high-speed, high-efficiency, low-overhead paper & fabric handling.
 - TMI – Attractors for inspection of nuclear boiler water reactor (BWR) facilities
- **ONR & NAVSEA HullBUG VRAM** – PI/Consultant for “Attractor Design for the Hull Biomimetic Underwater Grooming (HullBUG) Technology” and “HullBUG VRAM Design Optimization”. (2006–2009).

ShelfWorks Technologies: 2002 – 2006 (*spinout from Avionic Instruments*)

- **Charter Officer** (2004-2006).
 - Supported launch from **Avionic Instruments** (2002-2004)
 - Direct military product development, support commercial product development, sales & marketing
 - Bed, Bath & Beyond
 - Home Depot
 - Support IP Portfolio & Legal

Nekton Research (iRobot [IRBT]): 1998 - 2002

- **Vice President of R&D** (1998-2000) and **Director of Business Development** (2000-2002).
 - **Lead:** Cross-functional teams in marine-focused product/business development, production, deployment.
 - **IP Portfolio:** Co-inventor on USPTO# 6,378,801 (2002)
 - **Spinout:** Support incubation/launch of Parata Systems, a pharmacy automation company (1999-2002)
 - **M&A:** Provided early-stage due-diligence and introductions for acquisition by iRobot (2006)
- **Principal Investigator and Program Manager:**
 - **DARPA LSALS-SP3** – PI/PM for “3D Plume Tracing using Ranger™ MicroAUVs,” sponsored by DARPA – MTO. Joint effort with Sandia National Labs, and Woods Hole Oceanographic Institute. Developed multiple collaborative MicroAUVs that search for and localize plume sources and aircraft blackbox, to rescue and/or recover humans and assets.
 - **DARPA Distributed Micro-Robotics** – PI/PM for “Swimming Arrays for Anti-Submarine Warfare”, sponsored by DARPA – ATO. Joint effort with Draper Labs, Johns Hopkins University Applied Physics Lab, and Solers. Mobile acoustic array formations of multiple MicroAUVs. In contrast to towed arrays (e.g., TB-29), *Swimming Arrays* decouple tactical maneuvers from sensing maneuvers; enable protracted sensing, strong source direction discrimination, forward end-fire view, and dynamic array beamforming.
 - **DARPA Distributed Micro-AUVs** – PI/PM for “Aquatic Microbots”, sponsored by DARPA – MTO. Under *Distributed Robotics* program, design, build and demonstrate ultra-small AUVs, called “MicroHunters™”, which maneuver in 3D using only one moving part. Resulting navigation, called “Helical Klinotaxis” was validated on three different platforms and demonstrated to DARPA. Co-inventor on patent “3D Orientation for Aquatic Robots Using Helical Klinotaxis”, USPTO in April 2002.
 - **Forensics ROV** – PM and inventor of porthole-size ROV to perform forensic analyses of sunken assets. Based on a diametrically-opposed, large-diameter, low-velocity, vector thrusters, provide underwater telepresence to search for remains, assets and root-cause indicators. Unique design minimized silt disturbance, and maximized options for ingress and egress. (Private customer)
 - **Deepwater Towfish** – 6500m depth-rated towfish to carry sensor suite for applications in energy sector, telecommunications sector, sub-bottom profiling, and terrain mapping. (Private customer – EdgeTech)
 - **DARPA APLA/MGM** – PI/PM for “MicroHunter Guidance and Control of 60mm Mortars”, sponsored by DARPA – ATO. Under *Anti-Personnel Landmine Alternative/Minimally Guided Munitions* (APLA/MGM) program, collaborate with Battelle Memorial Institute to demonstrate feasibility, integrate microelectronic GNC sensors and actuators, and validate performance of single-actuator control force producer and guidance algorithm for indirect-fire munitions. Performance exceeded specifications.

Parata Systems: 1999 – 2002 (*spinout from Nekton Research serving as VP of Eng and Dir of BD*)

- Supported incubation and launch from **Nekton Research** (1999-2002)
 - Robotic System for Retail & Mass-Fulfillment Pharmacy
 - Technical & Business Development of Alpha- and Beta-level Products
 - Supported initial IP Portfolio

Duke University, Pratt School of Engineering: 1999 - 2021

- **Adjunct Associate Professor** (2005-2021) and **Adjunct Assistant Professor** (1999-2005).
 - Courses Taught Include:
 - Entrepreneurship & Tech Transition (Special Topics)
 - Robotics & Automation (MAE 442, ECE 383, ECE 142/442)
 - Control Theory (ECE 141/441)
- **MS Committee Member:** Serve on graduate student committees and advise research.
- **Advisor** and sponsor for Duke's Wall-Climbing Robot Team, which earned 1st place in the 2004 and 2005 International Climbing and Walking Robot (CLAWAR) Competitions in Madrid, Spain and London, England. Sponsored by the LORD Corporation and VortexHC.
- **Advisor** for Duke's DARPA Grand Challenge Team, in support of the Carnegie Mellon Red Team(s), which earned 2nd and 3rd places. Perception included RADAR, LIDAR, IMUs and GPS.
- **Advisor** and sponsor for Duke's Autonomous Underwater Vehicle (AUV) team, which earned finalist standings five times in the AUVSI/ONR International Autonomous Underwater Vehicle Competition. Participated in multiple annual competitions since 2001, with the following rankings: 2nd in 2006, 4th in 2005, 5th in 2004, 3rd in 2003, 4th in 2002, and 7th in 2001. Sponsored by LORD, VortexHC, and SeaBotix.

North Carolina State University, School of Engineering: 1992 - 2021

- **Adjunct Assoc Professor** (2009-2020), **Board Integrated Manufacturing Systems Engineering Institute** (1998 – 2020), **Adjunct Asst Professor** (2000-2009), **Instructor** (1996-1999), **Researcher** (1992-1996).
 - Teaching Experience:
 - Robotics & Automation (ECE 444, ECE 591)
 - Control Theory (ECE 435)
 - Distributed (Non-Deterministic, Network- & Statistics-based) Controls (ECE 492Z)
 - **MS Committee Member:** Serve on graduate student committees, sponsor, and advise research.
 - **Advisor & Corporate Sponsor** for NCSU's Autonomous Underwater Vehicle (AUV) team, which began participating in the AUVSI/ONR International AUV Competition. Participated in 2005 and 2006.
- **NASA-HELIOS** – PM for development and demonstration of semi-autonomous robotic system for lunar habitation and transport. Under NASA's Exploration Office, and funding from United Technologies, Caterpillar, and North Carolina Space Grant Consortium. Managed team of 40+ people to build and competitively demonstrate lunar exploration and habitation mission including deployment of lunar lander, UGV, and personnel habitat modules. Mission was demonstrated in full and earned first place and NASA's *1998 Extra Terrestrial Award*. January 1996 to April 1998.
- **DARPA/ONR Outdoor Landmark Recognition** – Researcher for "Outdoor Landmark Recognition Using Hybrid Fractal Vision System and Neural Networks", by DARPA and ONR. Validate new approach to detecting and recognizing outdoor landmarks using the Region-Feature Neural Network. (1993–1996)
- **Other Systems:** Bipedal robot (*Jenner*), a hexapod colony, an autonomous mobile robot (*Lazarus*), home automation & security based on decentralized control networks.

TMI Robotics: 1998 - 2013

- **President**
 - **Robotic & Automation Systems:** Submersible Robotic Hull Crawlers & Attractors for *General Electric*, *Hitachi*, *Framatome/Areva*, *SeaRobotics*, *SeaBotix*, etc. (2009-2018); wall-climbing robots for *SignalScape* (2009-2013); Pioneer mobile robot end-effector and bipedal robot for *Adept MobileRobots* (1998-2004); decentralized fuel pump control systems for *Gilbarco* (1998); Autonomous Following Golf Caddy for *Caddy Master* (1998-1999); Universal rotary actuator system for *Real World Interface (RWI)* and *iRobot (IS Robotics)* (1998-2000), etc.
 - **Artificial Intelligence Software and Textbook:** "Computational Intelligence: Supervised and Unsupervised Learning with Neural Networks", J.A. Janét and J.C. Sutton III. Copyright © 1998-2013. ISBN #0-9678493-0-6. Textbook included a time-limited single-user license for neural network software by TMI Robotics, Inc. Software included data, the Region-Feature Neural Network and the Hyper-Ellipsoid Clustering Neural Network for pattern analysis and machine intelligence. End-users/clients include *NCSU*, *National Technological University (NTU)* and *Video Based Engineering Education (VBEE)*, *IBM*, etc.

Other Professional Highlights:

- **Intellectual Property Litigation Expert Witness:** Provided reports, descriptive imagery and testimony for litigation regarding intellectual property, contracts and trade secrets. Cases are listed below, clients in **bold**:
 - Hesai v. **Ouster** (2024-pres) [USPTO PTAB IPR2023-01421]
 - Hesai v. **Ouster** (2024-pres) [USPTO PTAB IPR2023-01456]
 - Hesai v. **Ouster** (2024-pres) [USPTO PTAB IPR2023-01457]
 - Hesai v. **Ouster** (2024-pres) [USPTO PTAB IPR2023-01422]
 - A360 v **Toyota/Bastian** (2024-pres) [No. 1:23-cv-00198-JRS-TAB, Southern District of Indiana]
 - **Motive** v Samsara (2024-pres) [U.S. International Trade Commission]
 - **Good Sportsman** v Hangzhou ZH Tech [USPTO PTAB PGR]
 - **Tesla** v Autonomous Devices (2024-pres) [USPTO PTAB (IPR)] ‘474 Patent
 - **Becton Dickenson** v **JFCRx** (2023-2024) [Contract, trade secret compliance/audit]
 - Juul v **NJOY** – (2023-pres) [ITC] and [District Court of DE]
 - Textron v **DJI** – (2023-2024) [Case No. 2:22-cv-351-RWS-RSP (E.D. Tex)]
 - Solmetex v. **Dental Recycling** (2023-pres) [Pre-IPR: USPTO]
 - **Daifuku** v. ControlLogix [Pre-IPR: USPTO]
 - Autonomous Devices v **Tesla** (2023-pres) [C.A. No. 22-1466 (MN), District Court of DE]
 - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01172] ‘583 Patent
 - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01055] ‘344 Patent
 - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01054] ‘974 Patent
 - **Tesla** v Autonomous Devices (2023-pres) [USPTO PTAB IPR2023-01169] ‘134 Patent
 - **Tesla** v Autonomous Devices (2023-2024) [USPTO PTAB IPR2023-01170] ‘449 Patent
 - **Tesla** v Autonomous Devices (2023-2024) [USPTO PTAB IPR2023-01171] ‘585 Patent
 - Autonomous Devices v **Tesla** (2023-pres) [Case No. 1:22-cv-01466, District Court of DE]
 - **Ouster** v. Hesai et al, Lidar Systems (2023-2024) [337-TA-1363, U.S. International Trade Commission]
 - **Ouster** v. Hesai et al, (2023-pres) [No. 1:23-cv-00406, District Court of DE]
 - **Boston Dynamics** v Ghost Robotics (2023-pres) [1:22-cv-01483-MN, District Court of DE]
 - Vivint v **SkyBell** Technologies (2022-pres) [2:21-cv-09472, Central Dist of DC]
 - Moog v **SkyRyse** (2022-2024) [1:22-cv-00187, Western Dist of NY]
 - Velodyne v **Ouster** (2022-pres) [337-TA-1322, U.S. International Trade Commission]
 - **IQRIS** v Point Blank (2022-2023) [21-CV-61976-BB, Southern District of FL]
 - **Opex** v HC Robotics/Invata (2022) [337-TA-1293, U.S. International Trade Commission]
 - **iAqua** v Cayago (2022) [Reexam-EPR814 of 90/014,995 USPTO]
 - Cayago v **iAqua** (2022) [21-CV-61035, Southern District of FL]
 - Cayago v **iAqua** (2022) [Civil No. 21-1212, Puerto Rico]
 - Bacon Sons v **Perception Robotics** (2021-2022) [Case No: 30-2018-01000372, Orange Co, CA]
 - **AutoStore** v Ocado (2021-2023) [IPR2022-00443 USPTO]
 - **AutoStore** v Ocado (2021-2022) [IPR2022-00673 USPTO] (pre-institution)
 - **AutoStore** v Ocado (2021-2022) [IPR2021-00274 USPTO]
 - **AutoStore** v Ocado (2021-2022) [IPR2021-00311 USPTO]
 - **AutoStore** v Ocado (2021-2022) [IPR2021-00398 USPTO] (pre-lit)
 - **AutoStore** v Ocado (2021-2022) [IPR2021-00412 USPTO] (pre-lit)
 - **AutoStore** v Ocado (2021-2022) [PGR2021-00038 USPTO] (pre-lit)
 - **AutoStore** v Ocado (2021-2022) [HP-2020-000035, United Kingdom]
 - **AutoStore** v Ocado (2021-2022) [Spain – Pre-lit]
 - **AutoStore** v Ocado (2021-2022) [Case No. 2:20-cv-494, Eastern District of VA]
 - Ocado v **AutoStore** (2021-2022) [1-21-cv-00041, USDC - DNH]
 - Ocado v **AutoStore** (2021-2022) [1-21-cv-00806, USDC - DNH]
 - **iRobot** v SharkNinja (2021-2022) [337-TA-1252, U.S. International Trade Commission]
 - **Airborne Systems** v Wamore – Steerable parachute systems (2019-pres) [Arbitration – NJ]
 - **AutoStore** v Ocado (2020-2021) [337-TA-1228, U.S. International Trade Commission]
 - Interactive Play Devices v **Spin Master** (2020-2021) [Civil Action File No. 6:20-cv-00066, W.D. TX]
 - **DJI** v Autel – (2017-2021) RC UAV Systems [C.A. No. 16-706-LPS-CJB, District Court of DE]
 - Velodyne v **RoboSense** (2019-2020) [337-TA-1173, U.S. International Trade Commission]
 - Odyssey Marketing v **Spin Master** (2018) Unmanned Air Vehicles [IPR, USPTO]
 - Mattel v **Spin Master** (2018) Transformable Devices [IPR2018-01672, USPTO]

- **Mattel v Spin Master** (2018) Transformable Devices [IPR2018-01673, USPTO]
- **Mattel v Spin Master** (2018) Transformable Devices [IPR2018-01674, USPTO]
- **MPV v DJI** – (2018) [Case No. 2:18-cv-02210-RGK-AGR, Central District Court of CA]
- **Samsung v Cywee** – (2017) IMU Pose & AR [Case No. 2:2017cv00140, Eastern District of TX]
- **DJI v Autel** – (2017-2018) [2:17-cv-00776-RAJ, Western District of WA]
- **Synergy Drone v DJI** – (2017-2018) [Case No. 1:17-cv-00242, TX Western District Court]
- **iRobot v Bissell** – (2017-2018) [337-TA-1057, U.S. International Trade Commission]
- **Hayward Industries** – (2015-2016) Evaluate IP and Enabling Technologies for Submersible Systems
- **Choirock v Spin Master** (2016-2018) Transformable Devices [Case No. IPR2017-00030, USPTO]
- **Spin Master v Sphero, Inc.** (2016-2017) [Case No. IPR2017-01272, USPTO]
- **Sphero, Inc. v Spin Master Ltd.** (2017) [New York Southern District Court, Case No. 1:17-cv-05428]
- **Razor/Chen/Inventist v Jetson Electric Bikes** (2016-2017) [337-TA-1000, U.S. Int. Trade Commission]
- **Razor/Chen/Inventist v Powerboard** (2016-2017) [337-TA-1000, U.S. International Trade Commission]
- **Segway/DEKA/Ninebot v Jetson** (2016-2017) [337-TA-1007, U.S. Int. Trade Commission]
- **Segway/DEKA/Ninebot v Powerboard** (2016-2017) [337-TA-1007, U.S. Int. Trade Commission]
- **Segway/DEKA/Ninebot v Jetson** (2016-2017) [337-TA-1021, U.S. Int. Trade Commission]
- **Segway/DEKA/Ninebot v Powerboard** (2016-2017) [337-TA-1021, U.S. Int. Trade Commission]
- **DJI v Yuneec** [No. 5:16-cv-595, U.S. District Court, Central District of CA]
- **Rehco LLC v Spin Master Ltd.** (2015-2020) [No. 1:2013cv02245, Northern District of IL]
- **Segway/DEKA v Ninebot** [Inv. No. 337-TA-935, U.S. International Trade Commission]
- **Segway v Shenzen Inmotion** – [Inv. No. 337-TA-935, U.S. International Trade Commission]
- **ScriptPro v Innovation** – Pharmacy Automation (2015) [2:06-cv-2468-CM-JPO U.S. Dist Court, KS]
- **ScriptPro v Innovation** – Pharmacy Automation (2011-2015) [06-2468-CM U.S. District Court, KS]
- **Spinmaster v YourStoreOnline** – Wall-Climbers (2009-2010) [CV 09-5803 CAS]
- **SpinMaster v YourStoreOnline** – RC Helicopters (2009-2010) [CV 09-2121 CAS]
- **Patent Inventorship:** Other patents pending
 - 6,378,801: Devices and methods for orienting and steering in three-dimensional space.
 - 7,726,514: Automated article dispensation mechanism.
 - 8,091,733: Automated article dispensation mechanism.
 - 8,751,035: Automated laundry drop-off and retrieval system.
 - 9,664,813: Automated Insect Monitoring
 - 9,999,211: Automated Insect Monitoring (Removable Chambers with Transparent Sides for Inspection)
 - 9,999,212: Automated Insect Monitoring (Signal Processing to Detect and Recognize Invasive Pest)
 - 11,382,324: Insect Traps and Monitoring System (IoT Monitoring System with Detect/Classify Ability)
- **Board of Directors/Advisors Experience:** Provide strategic technology, business and corporate expertise.
 - **Delta Five** – Distributed unattended sensors, automation, SaaS and IoT.
 - **Panacea BioMatx Inc** - Automated customized medications and nutraceuticals. (www.panacea.me)
 - **Lelear** – Automated storage and retrieval systems.
 - **RxMedic** – Automation for preparing prescription orders in retail, government, and hospital pharmacies.
 - **VortexHC** – Non-dexterous gripping, robot climbers (air and underwater), and 6DOF holonomic AUVs.
 - **NCSU Integrated Manufacturing Systems Engineering Institute** – Multi-disciplinary graduate school

Selected Publications (of ~40)

- IoT Solutions Enabling Hotelier's to Monitor for Bed Bugs, www.deltafive.com/wp-content/uploads/2018/06/DeltaFive_BedBugAwarenessWeek2018_PressRelease.pdf, June 2018.
- New York City Challenged by Bed Bugs, www.newswire.com/news/new-york-city-challenged-by-bed-bugs-delta-five-offers-green-solution-20043137, November 2017.
- On the Heels of the Largest Bed Bug Lawsuit Judgement, Delta-Five Has a Proven Green Solution for Hotels, www.newswire.com/news/on-the-heels-of-the-largest-bed-bug-lawsuit-judgement-delta-five-has-a-19990567, October 2017.
- Hoteliers Find Delta Five's Innovative Bed Bug Solution Catches Bugs Faster and More Consistently, www.newswire.com/news/hoteliers-find-delta-fives-innovative-bed-bug-solution-catches-bugs-19940513, September 2017.

- As Hoteliers Look to Combat Bed Bug Rise Delta Five Offers Researched Solution, www.newswire.com/news/as-hoteliers-look-to-combat-bed-bug-rise-delta-five-offers-researched-19846348, August 2017.
- Green Approach to Prevention and Early Detection, www.eprnews.com/delta-five-highlights-green-approach-to-prevention-and-early-detection-during-bed-bug-awareness-week-138925/, June 2017
- Delta Five Raises the Bar in Battle Against Bed Bugs, www.newswire.com/news/delta-five-raises-the-bar-in-battle-against-bed-bugs-19547330, May 2017.
- Automated Bed Bug and Insect Monitoring System, www.newswire.com/news/delta-five-launches-automated-bed-bug-and-insect-19224593, April 2017.
- “Think It, Build It, Win It: Vision-Based Robot Design Secures Teledyne a \$350M NASA Engineering Contract” H. Neale. *NASA Tech Briefs* 2013/2014.
- “Automation is Changing Pharmacy: How Reducing Repetition Behind the Counter Improves Over the Counter Care” J. Janét. October 2010. *Insight Magazine*.
- “Automate Your Profits” J. Janét. October 2009. *Insight Magazine*.
- DTIC #ABV 299170 (NATICK/TR-04/013L): “Vortex Regenerative Air Movement: Attraction and Attachment on Vertical and Inverted Surfaces— A Simple Method for Static and Mobile Robots for Climbing Walls and Ceilings” J. Janét, D. Reinfeld, B. Wiedeman. October 2003. (Contract No. DAAD16-00-C-9259; US Army Soldier Systems Command, Natick, MA)
- DTIC #AD B267 288 (NATICK/TR-01/009L): “MicroHunter Control Applications for Elimination of Anti-Personnel Landmines: Low-Cost, Minimally Guided Munitions – A Simple Method for Controlling the Trajectory of Spinning Projectiles” M. Kemp, J. Janét, and C. Pell. May 2001. (Contract No. DAAN02-98-C-4030; US Army Soldier Systems Command, Natick, MA)
- “Development of a Micro Autonomous Underwater Vehicle for Complex 3-D Sensing”, *IEEE/MTS Oceans 2001 Conference*; Honolulu, HI; Nov 2001; B. Hobson, B. Schulz, J. Janet, R. Moody, C. Pell, and H. Pinnix.
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- “Assessing the Performance of Oscillating Fin Thruster Vehicles”, *Unmanned Untethered Submersible Technology (UUST)*; August 2001; Durham, NH; M. Kemp, B. Hobson, J. Janét, C. Pell, and E. Tytell.
- “Using Control Networks to Control Multiple Autonomous Mobile Robots: Biped, a Hexapod Colony, and a Complex Autonomous Mobile Robot”, *IEEE Int’l Conf. on Robotics & Automation*; Detroit, MI; May 1998; J. Janet, B. Wiseman, R. Michelli, S. Scoggins, and A. Walker.
- “Autonomous Mobile Robot Global Self-Localization Using Kohonen and Region-Feature Neural Networks”, *Jnl of Robotic Systems*; Vol. 14, No.4, 1997; J. Janet, R. Gutierrez, T. Chase, M. White, J. Sutton.
- “Combining Self-Organizing Geometric Certainty Maps with the Unscented Kalman Filter”, *Proc. of IEEE Int’l Conf. on Robotics & Automation*; Leuven, Belgium; May 1998; J. Janét, J. Brickley, M. Kay, M. White, and J. Sutton.
- “Modeling of Sonar Sensors for Localization of Autonomous Mobile Robots”, *IEEE Transactions on Industrial Electronics*; October 1998; R. Gutierrez, J. Janet, and R. Luo.
- “Autonomous Mobile Robot Global Motion Planning and Geometric Beacon Collection Using Traversability Vectors”, *IEEE Trans on Robotics & Automation*; Vol.13, No.1, 1997, Pages:132–140; J. Janét, M. Kay, and R. Luo.

Skills Brief

- *Executive Leadership*. Provided fiscal, strategic, IP and operational leadership in application and development of heavily engineered systems for software, robotics and automation, medical, pharmacy, maritime, aviation, government, military, law enforcement, security, entertainment, hospitality, analytics, pattern analysis, and energy markets. Demonstrated ability to develop and implement business plans, integrate emerging technologies, raise capital, be an effective change agent, and transition product and client service concepts to commercial viability. Effective collaborator with companies, academic institutions, military, government and foreign entities. Experienced with legal aspects of launch, operations, equity, M&A, intellectual property & litigation. Successful manager of sales, marketing and finance including, ROI tool development, market research, prospecting, sales presentations, competitive analysis, brand development, multi-media advertising, contract negotiation, deal closure, A/P and A/R.

- *Board Member.* Effective strategic contributor and communicator on behalf of corporations (Delta Five, RxMedic, Panacea Biomatix, Lealear, and VortexHC) and an academic institution (NCSU IMSEI).
- *Engineering and Product Development.* Demonstrated ability to develop and deploy hardware and software products, including automated retrieval systems, fixed-base robots, medical systems, mobile robots, autonomous and remote-control unmanned ground robots, wall-climbing robots, hull inspection & cleaning robots, nuclear vessel inspection robots, autonomous underwater vehicles, non-destructive inspection robots, retail automation, and mine neutralization robots.

Additional

- **Security Clearance.** Personal clearance level – TOP SECRET & SCI. Facilities Security Officer (FSO) for Vortex HC. Coordinated processing of SECRET level Facility Clearances (FCL) and Personnel Clearances (PCL).
- **Institute of Electrical & Electronic Engineers (IEEE):** Robotics, Controls & Pattern Analysis.
- **Autonomous Unmanned Vehicle Systems International (AUVSI)**
- **American Society for Engineering Education (ASEE)**
- **American Society of Mechanical Engineers (ASME)**
- **PADI SCUBA:** Professional diver for underwater mobile robots, hull inspection, underwater video, counter-mine, ASW, etc.
- **Commercial Driver's License:** Class-A CDL, base registrations in North Carolina (and Virginia).
- **USPA Skydiving:** (1991 – 1997) USPA Jumpmaster certification in 1996. D-license with 400 jumps including instruction, tandem master training support, demonstrations, accuracy, and freefall relative work (RW). National collegiate RW championship team in 1994 (Richmond, IN). Carolina Sky Sports Accuracy Champion in 1993 (Louisburg, NC).
- **Pyrotechnician:** Class-A/B levels.
- **Master Mason:** Foundation of ~20 years of construction experience, primarily with ornamental stone, brick, and concrete. Experience initially gained as a youth within family-owned and operated business (Dogwood Quarries) in DC-metropolitan area; summers and school breaks from 1981 until 1997. Since 1998, all work has been *pro bono* including for Habitat for Humanity.

Computer Tools

Proficient: SalesForce, PowerPoint, Excel, Word, Project, MATLAB

Prior experience: Epicor ERP, QuickBooks, AutoCAD, SolidWorks, OrCAD, LabView, C/C++, Assembly