

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Shelton
U.S. Patent No.: 11,703,602 Attorney Docket No: 013639.00051
Issue Date: July 18, 2023
Appl. Serial No.: 17/845,115
Filing Date: Jun. 21, 2022
Title: TRAFFIC RADAR SYSTEM WITH PATROL VEHICLE
SPEED DETECTION

DECLARATION OF DR. BRIAN W. ANTHONY

TABLE OF CONTENTS

I.	SUMMARY OF THE '602 PATENT	6
A.	Brief Description	6
II.	LEVEL OF ORDINARY SKILL IN THE ART	7
III.	CLAIM CONSTRUCTION UNDER 37 C.F.R. §§ 42.104(B)(3).....	8
A.	“a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle” (claims 1 and 9)	9
1.	First Interpretation (Grounds 1A, 1B, 2A, 2B): “a radar transceiver configured to transmit and receive radar beams [either] in a front zone ...or in a rear zone [but not both]”	9
2.	Second Interpretation (Ground 3): “a radar transceiver configured to transmit and receive radar beams [both] in a front zone ...or in a rear zone corresponding to an area behind the patrol vehicle”	10
IV.	PRIOR ART ANALYSIS.....	10
A.	Ground 1A: Claims 1-3, 6-11, 14, and 15 are obvious over Aker in view of Aker '724 and Thomas.....	10
1.	Overview of Aker.....	10
2.	Overview of Aker '724	11
3.	Overview of Thomas.....	12
4.	The combination of Aker, Aker '724, and Thomas	12
5.	Reasons to combine Aker and Aker '724	13
6.	Reasons to combine Aker/Aker '724 and Thomas	14
7.	Analysis.....	16
B.	Ground 1B: Claims 3-5 and 11-13 are obvious over Aker, Aker '724, and Thomas in view of Carmichael.....	37
1.	The combination of Aker, Aker '724, Thomas, and Carmichael	37
2.	Reasons to combine Aker, Aker '724, Thomas, and Carmichael.....	37
3.	Analysis.....	39
C.	Ground 2A: Claims 1-3, 6-11, 14, and 15 are obvious over Shelton in view of Henderson and Thomas	42

1. Overview of Shelton	43
2. Overview of Henderson	43
3. The combination of Shelton, Henderson, and Thomas	43
4. Reasons to combine Shelton and Henderson	44
5. Reasons to combine Shelton/Henderson and Thomas	46
6. Analysis	48
D. Ground 2B: Claims 3-5 and 11-13 are obvious over Shelton, Henderson and Thomas in view of Carmichael	70
1. The combination of Shelton, Henderson, Thomas and Carmichael	70
2. Reasons to combine Shelton, Henderson, Thomas and Carmichael	70
3. Analysis	72
E. Ground 3: Claims 1-15 are obvious over the '039 Publication in view of Jones	76
1. The '602 Patent is not entitled to its claimed priority date	76
2. The '039 Publication qualifies as prior art to the '602 Patent	78
3. Overview of Jones	78
4. The combination of the '039 Publication and Jones	79
5. Reasons to combine '039 Publication and Jones	79
6. Analysis	81
V. LEGAL PRINCIPLES	85
A. Anticipation	85
B. Obviousness	86

CLAIM LISTING

Limitation	Claim Language
[1.0]	A traffic radar system comprising:
[1.1]	a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle and to generate an electronic signal corresponding to the received radar beam;
[1.2]	a speed determining element configured to determine and output a speed of the patrol vehicle and not receive signals or data from the patrol vehicle; and
[1.3]	a processing element configured to
[1.4]	receive a plurality of digital data samples derived from the electronic signal,
[1.5]	receive the speed of the patrol vehicle from the speed determining element,
[1.6]	perform a time domain to frequency domain conversion on the digital data samples creating a plurality of frequency bins, each frequency bin associated with a frequency bin number, having a relative magnitude value, and corresponding to a speed of a vehicle,
[1.7]	convert the speed of the patrol vehicle to a frequency bin number,
[1.8]	form a patrol vehicle speed window that includes a range of frequency bin numbers having the frequency bin number of the converted patrol vehicle speed as a center of the range,
[1.9]	determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a spike threshold value,
[1.10]	convert one frequency bin number in each group to the relative speed of one target vehicle, and
[1.11]	convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.

Limitation	Claim Language
[2.0]	The traffic radar system of claim 1, wherein the processing element is further configured to perform one of the following depending the directions of travel of the patrol vehicle and the target vehicle:
[2.1]	add the relative speed of the target vehicle to the speed of the patrol vehicle to determine the absolute speed of the target vehicle,
[2.2]	subtract the relative speed of the target vehicle from the speed of the patrol vehicle to determine the absolute speed of the target vehicle, and
[2.3]	subtract the speed of the patrol vehicle from the relative speed of the target vehicle to determine the absolute speed of the target vehicle.
[3.0]	The traffic radar system of claim 1, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.
[4.0]	The traffic radar system of claim 1, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to determine that the patrol vehicle is moving when the patrol vehicle speed is greater than a first threshold value for a predetermined number of successive messages.
[5.0]	The traffic radar system of claim 1, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to determine that the patrol vehicle is stationary when the patrol vehicle speed is less than a second threshold value for a predetermined number of successive messages.

Limitation	Claim Language
[6.0]	The traffic radar system of claim 1, wherein the speed determining element is further configured to receive and process radio frequency signals from a global navigation satellite system.
[7.0]	The traffic radar system of claim 1, further comprising a display configured to display a plurality of speeds, and the processing element is further configured to control the display to display the speed of the patrol vehicle and the absolute speed of the target vehicle.
[8.0]	The traffic radar system of claim 1, further comprising an analog to digital converter configured to receive the electronic signal and output the digital data samples.
[9.0]	A traffic radar system comprising:
[9.1]	a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle and to generate an electronic signal corresponding to the received radar beam;
[9.2]	a speed determining element configured to receive and process radio frequency signals from a global navigation satellite system to determine and output a speed of the patrol vehicle; and
[9.3]	a processing element configured to
[9.4]	receive a plurality of digital data samples derived from the electronic signal,
[9.5]	receive the speed of the patrol vehicle from the speed determining element,
[9.6]	perform a time domain to frequency domain conversion on the digital data samples creating a plurality of frequency bins, each frequency bin associated with a frequency bin number, having a relative magnitude value, and corresponding to a speed of a vehicle,

Limitation	Claim Language
[9.7]	convert the speed of the patrol vehicle to a frequency bin number,
[9.8]	form a patrol vehicle speed window that includes a range of frequency bin numbers having the frequency bin number of the converted patrol vehicle speed as a center of the range,
[9.9]	determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a spike threshold value,
[9.10]	convert one frequency bin number in each group to the relative speed of one target vehicle, and
[9.11]	convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.
[10.0]	The traffic radar system of claim 9, wherein the processing element is further configured to perform one of the following depending the directions of travel of the patrol vehicle and the target vehicle:
[10.1]	add the relative speed of the target vehicle to the speed of the patrol vehicle to determine the absolute speed of the target vehicle,
[10.2]	subtract the relative speed of the target vehicle from the speed of the patrol vehicle to determine the absolute speed of the target vehicle, and
[10.3]	subtract the speed of the patrol vehicle from the relative speed of the target vehicle to determine the absolute speed of the target vehicle.
[11.0]	The traffic radar system of claim 9, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.
[12.0]	The traffic radar system of claim 9, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to

Limitation	Claim Language
[12.1]	determine that the patrol vehicle is moving when the patrol vehicle speed is greater than a first threshold value for a predetermined number of successive messages, and
[12.2]	determine that the patrol vehicle is stationary when the patrol vehicle speed is less than a second threshold value for a predetermined number of successive messages.
[13.0]	The traffic radar system of claim 12, wherein the processing element is further configured to set a mode of speed detection to moving when the processing element determines that the patrol vehicle is moving or to stationary when the processing element determines that the patrol vehicle is stationary.
[14.0]	The traffic radar system of claim 9, further comprising a display configured to display a plurality of speeds, and the processing element is further configured to control the display to display the speed of the patrol vehicle and the absolute speed of the target vehicle.
[15.0]	The traffic radar system of claim 9, further comprising an analog to digital converter configured to receive the electronic signal and output the digital data samples.

1. I, Brian W. Anthony, of Cambridge, MA, declare that:
2. My name is Dr. Brian W. Anthony. I am an Associate Principal Research Scientist at the Institute of Medical Engineering & Science at Massachusetts Institute of Technology (MIT). I am also a Principal Research Scientist at MIT's Mechanical Engineering department, Director of the Master of Engineering in Advanced Manufacturing and Design Program at MIT, Director of Health Technology at the MIT Center for Clinical and Translational Research, a Co-Director of the Medical Electronic Device Realization Center of the Institute of Medical Engineering & Science, and Associate Director of MIT.nano. My current *curriculum vitae* is attached and some highlights follow.
3. I earned my B.S. in Engineering (1994) from Carnegie Mellon University. I earned my M.S. (1998) and Ph.D. (2006) in Engineering from MIT. My research focused on high-performance computation, signal processing, and electro-mechanical system design.
4. In 1997, I co-founded Xcitex Inc., a company that specialized in video-acquisition, advanced instrumentation, and target tracking and video analysis and signal processing software. I served as the Chief Technology Officer and directed and managed product development until 2006. Our products included systems which combined video acquisition along with optical, acoustic, RF signals, acquisition and analysis and further integration with GPS systems. One such

system was used to analyze golfer and ball motions and velocities for the PGA tour broadcast; for this technology, I won an Emmy from the National Academy in recognition of technical innovations in broadcast television.

5. I joined MIT in 2006 and was the Director of the Master of Engineering in Advance Manufacturing and Design Program for over ten years. The degree program covers four main components: Manufacturing Physics, Manufacturing Systems, Product Design, and Business Fundamentals.

6. In 2011, I co-founded MIT's Medical Electronic Device Realization Center ("MEDRC") and currently serve as co-director. The MEDRC aims to create and deploy revolutionary medical technologies by collaborating with clinicians, the microelectronics, and medical devices industries. We combine expertise in computation; communications; optical, electrical, and ultrasound sensing technologies; and consumer electronics. We focus on the usability and productivity of medical devices using, for example, image and signal processing combined with intelligent computer systems to enhance practitioners' diagnostic intuition. Our research portfolio includes low power integrated circuits and systems, big data, micro electro-mechanical systems, bioelectronics, sensors, and microfluidics. Specific areas of innovation include wearable, non-invasive and minimally invasive optical biosensor devices, medical imaging, laboratory instrumentation,

and the data communication from these devices and instruments to healthcare providers and caregivers.

7. I am currently the Director of the Device Realization Lab, Co-Director of the Medical Electronic Device Realization Center (MEDRC), and Director Technical Operation of the Center for Clinical and Translational Research (CCTR) at the Institute of Medical Engineering & Science, and Associate Director of MIT.nano at MIT. The Device Realization Lab designs instruments and techniques to sense and control physical systems. Medical devices, autonomous systems, and manufacturing inspection systems are a particular focus. We develop and combine electromechanical systems, complex algorithms, and computation systems to create instruments and measurement solutions for problems that are otherwise intractable.

8. The research of the Device Realization Lab focuses on product development interests cross the boundaries of computer vision, acoustic and ultrasonic imaging, large-scale computation and simulation, optimization, metrology, autonomous systems, and robotics. We use computation, and computer science, as methodology for attacking complex instrumentation problems. My work combines mathematical modeling, simulation, optimization, and experimental observations, to develop instruments and measurement solutions. I've taught courses in instrumentation, and introduction to electrical engineering and

computer science concepts in signal processing, target identification, and tacking in the context of automation systems, communications systems, and medical systems.

9. My record of professional service includes recognitions from several professional organizations in my field of expertise. In addition, I am a named inventor on 10 issued U.S. patents. I have published approximately 100 papers, and have received a number of best paper and distinguished paper awards.

10. I have been retained on behalf of Applied Concepts Inc. to offer technical opinions relating to U.S. Patent No. 11,703,602 (“the ’602 patent,” ACI-1001) and prior art references relating to its subject matter. I have reviewed the ’602 patent and relevant excerpts of the prosecution history of the ’602 patent (ACI-1002). I have also reviewed the following prior art references and materials, in addition to other materials I cite in my declaration:

- ACI-1001: U.S. Pat. No. 11,703,602 to Shelton (“the ’602 patent”)
- ACI-1002: Prosecution History of the ’602 patent
- ACI-1004: U.S. Patent Pub. No. 2004/0257268 (“Aker”)
- ACI-1005: United Kingdom Patent Pub. No. 2,334,700 (“Thomas”)
- ACI-1006: U.S. Patent Pub. No. 2005/0146458 (“Carmichael”)
- ACI-1007: U.S. Patent No. 5,691,724 (“Aker ’724”)
- ACI-1008: U.S. Patent No. 6,023,236 (“Shelton”)

- ACI-1009: U.S. Patent No. 5,528,246 (“Henderson”)
- ACI-1010: U.S. Patent Pub. No. 2005/0062642 (“Aker ’642”)
- ACI-1014: U.S. Patent No. 11,194,039 to Shelton (“the ’039 Patent”)
- ACI-1015: U.S. Patent Pub. No. 2019/0107619 (“the ’039 Publication”)
- ACI-1016: U.S. Patent No. 5,898,400 (“Jones”)

11. Counsel has informed me that I should consider these materials through the lens of one of ordinary skill in the art related to the ’602 patent at the time of the earliest possible priority date of the ’602 patent, and I have done so during my review of these materials. The ’602 patent claims priority to an application filed October 9, 2017 (the “Critical Date”). Counsel has informed me that this Critical Date represents the earliest priority date to which the challenged claims of ’602 patent are possibly entitled, and I have therefore used that Critical Date in my analysis below (except where noted otherwise, *e.g.*, Ground 3).

12. I have no financial interest in the party or in the outcome of this proceeding. I am being compensated for my work as an expert on an hourly basis. My compensation is not dependent on the outcome of these proceedings or the content of my opinions.

13. In writing this Declaration, I have considered the following: my own knowledge and experience, including my work experience in the fields of mechanical engineering, computer science, biomedical engineering, and electrical

engineering; my experience in teaching those subjects; and my experience in working with others involved in those fields. In addition, I have analyzed various publications and materials, in addition to other materials I cite in my declaration.

14. My opinions, as explained below, are based on my education, experience, and expertise in the fields relating to the '602 patent. Unless otherwise stated, my testimony below refers to the knowledge of one of ordinary skill in the fields as of the Critical Date, or before. Any figures that appear within this document have been prepared with the assistance of Counsel and reflect my understanding of the '602 patent and the prior art discussed below.

I. SUMMARY OF THE '602 PATENT

A. Brief Description

15. The '602 Patent, titled "Traffic Radar System with Patrol Vehicle Speed Detection," issued on July 18, 2023 from an application filed on June 21, 2022. ACI-1001, Face. The patent claims priority to U.S. Patent No. 11,579,314 as a continuation, to U.S. Patent No. 11,194,039 (the '039 Patent) as a continuation-in-part, and to three provisional applications, the earliest of which was filed October 9, 2017. *Id.*

16. The '602 Patent describes a "traffic radar system" for use in a vehicle including "a first radar transceiver" directed towards the front of the vehicle, "a

17. “second radar transceiver” directed towards the rear of the vehicle, “a speed determining element” (*e.g.*, a speedometer), and “a processing element.” *Id.*, Abstract. The processing element analyzes digitized radio signals from the radar transceivers to identify targets and determine their speed relative to the vehicle, and then calculates the absolute speed of the target based on the measured speed of the vehicle from the speed determining element. *See id.* The processing element utilizes a well-known signal processing technique (a “fast Fourier transform” or “FFT”) to process the digitally-sampled radar return signal and “produce[] a plurality of frequency bins” each “having a relative magnitude value” representing the strength of the frequency associated with the bin in the received radar signal. *Id.*, 8:56-60. The use of the FFT algorithm in traffic radar systems was well-known in the art decades prior to the ’602 Patent. *See, e.g.*, ACI-1004, [0091]; ACI-1006, [0059]; ACI-1007, 22:39-23:3; ACI-1009, 4:42-64 (each describing performing an FFT on a digitally-sampled radar signal to produce frequency bins).

II. LEVEL OF ORDINARY SKILL IN THE ART

18. A person of ordinary skill in the art relating to, and at the time of, the invention of the ’062 Patent (“POSITA”) would have been a person with a working knowledge of Doppler radar systems. The person would have had a Bachelor of Science degree in an academic discipline emphasizing electrical, mechanical, instrumentation engineering or other disciplines related to signal processing or

measurement science, in combination with specific training or at least one to two years of related work experience with Doppler radar systems. Alternatively, the person could have also had a Master of Science degree in electrical, mechanical, instrumentation engineering or other disciplines related measurement science engineering with less than a year of related work experience in the same discipline.

19. Based on my experiences, I have a good understanding of the capabilities of a POSITA. Indeed, I have taught, participated in organizations, and worked closely with many such persons over the course of my career.

20. I have performed my analysis through the lens of a POSITA as of the Critical Date.

III. CLAIM CONSTRUCTION UNDER 37 C.F.R. §§ 42.104(B)(3)

21. I understand that, for purposes of my analysis in this inter partes review proceeding, the terms appearing in the patent claims should generally be interpreted according to their “ordinary and customary meaning.” *See Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (en banc). I understand that “the ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention.” *Id.* at 1313. I also 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. *Id.*

22. In addition, I apply the claim interpretations described below.

A. **“a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle” (claims 1 and 9)**

23. Two alternative interpretations of this claim term are applied herein.

Grounds 1A, 1B, 2A, and 2B apply the First Interpretation, and Ground 3 applies the Second Interpretation.

1. **First Interpretation (Grounds 1A, 1B, 2A, 2B): “a radar transceiver configured to transmit and receive radar beams [either] in a front zone ...or in a rear zone [but not both]”**

24. Under this interpretation, the claimed radar transceiver is configured to transmit and receive radar beams either in a front zone or in a rear zone, but not both. The specification of the '602 Patent supports such an interpretation by describing a “front radar transceiver” that “may be mounted or installed on the forward portion of the patrol vehicle” and that transmits radar beams “in front of the patrol vehicle,” and a “rear radar transceiver” that “may be mounted or installed on the rear portion of the patrol vehicle” and that transmits radar beams “in the rear of the patrol vehicle.” ACI-1001, 4:29-5:24.

2. Second Interpretation (Ground 3): “a radar transceiver configured to transmit and receive radar beams [both] in a front zone ...or in a rear zone corresponding to an area behind the patrol vehicle”

25. Under this interpretation, likely to be advanced by Patent Owner in the co-pending litigation, the claimed radar transceiver is configured to transmit and receive radar beams both in a front zone or in a rear zone, which requires the radar transceiver to be directional. As discussed in greater detail below, if the claim is interpreted in this manner, the '602 Patent is not entitled to its claimed priority because an element of its priority chain (the '039 Patent) fails to provide written description support for this claim feature.

IV. PRIOR ART ANALYSIS

A. Ground 1A: Claims 1-3, 6-11, 14, and 15 are obvious over Aker in view of Aker '724 and Thomas

1. Overview of Aker

26. Aker discloses a “traffic radar” system “with direction sensing capability” in which reflected radar signals “are digitized and the samples are processed by a digital signal processor programmed to find one or more selected target speeds.” ACI-1004, Abstract, [0001], [0052]. Aker discloses that a “microwave antenna is used to transmit outgoing radar beams and receive reflected radar energy from moving and stationary objects,” and the reflected energy is used to calculate target speed. *Id.*, [0042]. Aker further discloses a “preferred two

antenna embodiment” where “two antennas are located on the front and rear of the patrol car.” *Id.*, [0056], [0057].

27. Aker discloses that the “patrol car speed” (*i.e.*, the ground speed of the vehicle containing the radar system) “can be determined from the car's speedometer (as opposed to processing returns from stationary objects such as the ground),” and discloses “an optional speedometer link transducer 59 provides a signal or data to the DSP from which the indicated speed on the speedometer can be determined for use in moving mode target speed calculations.” *Id.*, [0051].

28. Aker further discloses that the operation of its traffic radar system is further detailed in the Aker '724 patent, which Aker incorporates by reference. *See, e.g.*, ACI-1004, [0004] (“The Stalker Dual radar is fully described in U.S. Pat. No. 5,691,724 which has an effective filing date of Feb. 10, 1995, the full contents of which are hereby incorporated by reference.”), [0052], [0053], [0054], [0084], [0094], [0110].

2. Overview of Aker '724

29. Similar to Aker, Aker '724 discloses a “police radar utilizing digital data transmission from the antenna unit to a separately housed counting and display unit.” ACI-1007, Abstract. Aker '724 provides additional detail on aspects of the processing of samples of the received radar energy using fast Fourier

transforms by the digital signal processor (DSP). ACI-1004, [0053], [0054]; ACI-1007, 22:1-6, 23:41-63.

3. Overview of Thomas

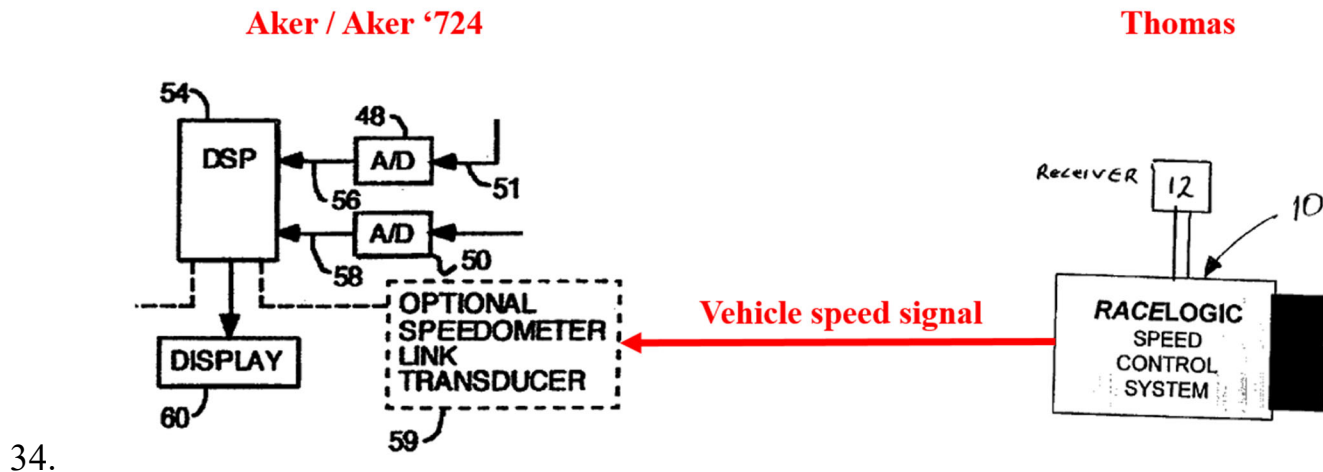
30. Thomas relates to a device “for a vehicle engine which is designed to restrict the vehicle speed automatically.” ACI-1005, Abstract. One component of the device is a “controller 10” that “includes a receiver 12 to receive a signal from...global positioning satellites.” *Id.*, 4:33-5:3. The controller 10 “calculate[s]” a “current-vehicle-speed signal...from GPS (global positioning data).” *Id.*, 2:8-10; *see also* 7:7-8:1 (“The information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor 22 input.”). In Thomas’s system, the controller 10 outputs the “current-vehicle-speed signal” to a comparator which compares it to a speed limit signal. *Id.*, 4:33-5:16.

4. The combination of Aker, Aker ’724, and Thomas

31. In the combination, the traffic radar system of Aker is further detailed in the Aker ’724 patent, which Aker incorporates by reference. *See, e.g.*, ACI-1004, [0004] (“The Stalker Dual radar is fully described in U.S. Pat. No. 5,691,724 which has an effective filing date of Feb. 10, 1995, the full contents of which are hereby incorporated by reference.”), [0052], [0053], [0054], [0084], [0094], [0110].

32. In addition, in the combination, the traffic radar system disclosed in Aker and Aker '724 is modified such that the controller 10 from Thomas (including the GPS receiver 12) provides a “current-vehicle-speed signal” calculated based on the GPS data to the “speedometer link transducer 59” of the DSP in the counting display unit disclosed in Aker.

33. The following composite of FIG. 1 from Aker and FIG. 1 from Thomas shows the asserted combination:



5. Reasons to combine Aker and Aker '724

35. A POSITA examining Aker would have looked to Aker '724 for more information on the operation of the Aker's traffic radar system because Aker repeatedly and specifically directs the reader to Aker '724 for just such information. *See, e.g.*, ACI-1004, [0004], [0052], [0053], [0054], [0084], [0094], [0110]. Even if the text of Aker '724 were not part of Aker by virtue of Aker incorporating “the full contents” Aker '724 by reference, a POSITA would

nonetheless have been motivated to obtain more information when implementing the traffic radar system described in Aker, and would have been directed to Aker '724 by Aker's specific instructions. The result of this combination would have been predictable because Aker and Aker '724 describe the same system, and thus this portion of the combination involves no material change to the traffic radar system of Aker.

6. Reasons to combine Aker/Aker '724 and Thomas

36. It would have been obvious to a POSITA to modify the Aker/Aker '724 radar system to receive current vehicle speed data from a GPS-enabled speedometer, as taught by Thomas. Aker discloses receiving a current vehicle speed from a speedometer, without limitation to any specific type of speedometer and thus is compatible with a GPS speedometer such as that disclosed in Thomas. *See* ACI-1004, [0054], [0061], [0099]. Thomas discloses a GPS speedometer, and states that “[t]he information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor input.” ACI-1005, 7:32-8:1. Thomas discloses such sensors as “largely mechanical and tend to be complex and expensive to fit to a vehicle.” *Id.*, 1:12-13. Eliminating such sensors may simplify the vehicle design, leading to a more robust final product. Further, in the event of an issue with the existing speedometer in a vehicle, such as inaccuracy or mechanical issue, a POSITA would have been

motivated to incorporate Thomas' GPS speedometer, which Thomas emphasizes "can be retro-fitted to 99% of cars on the road today." ACI-1005, 4:30-31.

37. In addition, Thomas stresses the ease with which its GPS speedometer can be incorporated into a vehicle, stating that the "controller 10 of the present invention can be connected to almost any vehicle in the world" (*id.*, 4:15-16), and that "[t]he controller can be retro-fitted to 99% of cars on the road today" with an "[a]verage installation tak[ing] around 3 hours" (*id.*, 4:30-31). While ease of performing a combination does not necessarily represent a motivation for a POSITA to do so, these quotes make clear that incorporating Thomas's GPS-enabled speedometer would have been accomplished by a POSITA.

38. Further, a POSITA would have found it obvious to modify Aker based on Thomas's teachings because doing so entails the use of known solutions to improve similar systems and methods in the same way. Here, "when a patent 'simply arranges old elements with each performing the same function it had been known to perform' and yields no more than one would expect from such an arrangement, the combination is obvious." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized that applying Thomas's teachings to augment Aker would have led to predictable results without significantly altering or hindering the functions performed by Aker's system.

39. In fact, a POSITA would have been motivated to incorporate the well-known techniques of Thomas into Aker to achieve the predictable benefits disclosed in Thomas. *See, e.g.*, ACI-1005, 1:12-13, 7:32-8:1. Indeed, a POSITA would have had a reasonable expectation of success incorporating Thomas's teachings into Aker, because both Aker and Thomas disclose a device operating in the proposed manner. ACI-1004, [0051] ("an optional speedometer link transducer 59 provides a signal or data to the DSP from which the indicated speed on the speedometer can be determined for use in moving mode target speed calculations."); ACI-1005, 1:12-13, 2:8-10, 4:33-5:16, 7:7-8:1.

40. Accordingly, for at least these reasons, augmenting Aker's device based on the teachings of Thomas would have been routine and straightforward to a POSITA, and it would have been clear that such a combination would predictably work and provide the expected results. *Id.*

7. Analysis

41. In the co-pending litigation, Patent Owner currently asserts claims 9-14 of the '602 Patent. Accordingly, for all Grounds in the present Petition, independent claim 9 and its dependent claims are addressed first, with non-asserted independent claim 1 and its dependents addressed subsequently.

a) Claim 9

[9.0]: "A traffic radar system comprising"

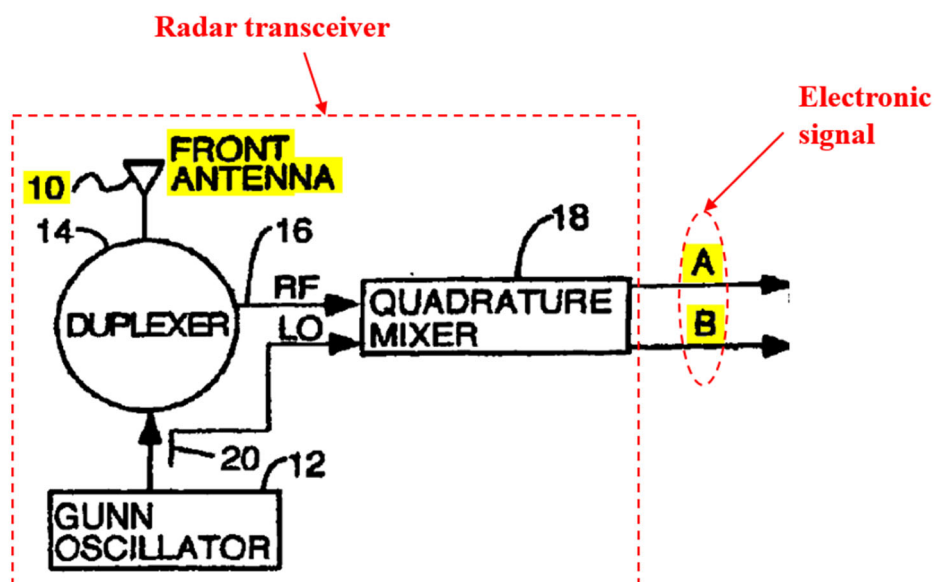
42. To the extent the preamble is deemed limiting, the combination of Aker, Aker '724, and Thomas (hereinafter the “Aker-Thomas combination”) renders it obvious. For example, in the combination, Aker discloses a “traffic radar” system “with direction sensing capability” in which reflected radar signals “are digitized and the samples are processed by a digital signal processor programmed to find one or more selected target speeds.” ACI-1004, Abstract, [0001], [0052]. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.1]: “a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle and to generate an electronic signal corresponding to the received radar beam”

43. In the combination, Aker discloses that a “***microwave antenna***” (radar transceiver) “is used to ***transmit outgoing radar beams*** and ***receive reflected radar energy*** from moving and stationary objects.” ACI-1004, [0042]. The reflected radar energy will include reflected radar beams and/or scattered reflected radar signals depending on the orientation and properties of the reflecting surface on the target object. *See id.* “Duplexer 14 is used to...guide reflected energy received by antenna 10 out on line 16 to quadrature mixer 18.” *Id.* “The function of the quadrature mixer is to mix local oscillator energy with incoming RF of reflected waves in two separate mixers in two separate channels and shift one channel 90 degrees relative to the other channel.” *Id.*, [0043]. Collectively, these channels

(referred to as “channel A” and “channel B” in Aker) are a first electronic signal corresponding to the received radar beam. *See id.*, [0043]-[0046].

44. Aker further discloses a “*preferred two antenna embodiment*” where “*two antennas are located on the front and rear of the patrol car.*” ACI-1004, [0056], [0057]. The following annotated detail of FIG. 4 of Aker shows the front antenna unit (the radar transceiver):



ACI-1004, Detail of FIG. 4 (annotated)

45. Under the First Interpretation of this limitation, either the front or rear antennas from Aker disclose a “radar transceiver configured to transmit and receive radar beams in a front zone...or in a rear zone.” Aker’s front antenna is configured to transmit and receive in a front zone (but not the rear), and its rear antenna is configured to transmit and receive in a rear zone (but not the front).

See, e.g., ACI-1004, [0056], [0057]. Under the First Interpretation, the radar transceiver need only be configured to transmit and receive in either the front zone or the rear zone, so under this interpretation the limitation is satisfied by either of Aker's antennas. See ACI-1004, [0056], [0057].

46. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.2] “a speed determining element configured to receive and process radio frequency signals from a global navigation satellite system to determine and output a speed of the patrol vehicle; and”

47. In the combination, Thomas discloses a “controller 10” (*i.e.*, a speed determining element) that “includes a receiver 12 to ***receive a signal from...global positioning satellites.***” ACI-1005, 4:33-5:3. The controller 10 “***calculate[s]***” a “***current-vehicle-speed signal...from GPS (global positioning data).***” *Id.*, 2:8-10; see also 7:7-8:1 (“The information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor 22 input.”). In Thomas's system, the controller 10 outputs the “current-vehicle-speed signal” to a comparator which compares it to a speed limit signal. ACI-1005, 4:33-5:16.

48. As described above, in the present combination, the controller 10 from Thomas (including the GPS receiver 12) provides a “current-vehicle-speed signal” calculated based on the GPS data to the “speedometer link transducer 59” of the

DSP in the counting display unit (processing element, *see* [9.3]) disclosed in Aker. ACI-1004, [0051]. In addition, as described above, a POSITA would have both found the combination obvious and been motivated perform the combination.

49. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.3]: “a processing element configured to”

50. In the combination, Aker discloses a “***digital signal processor 54***” (a processing element), referred to throughout as a “DSP.” ACI-1004, [0048]. Aker discloses that the “function of the digital signal processor 54 is to process the digital samples from channels A and B...to determine a target speed and display it.” *Id.*, [0049]. Accordingly, the Aker-Thomas combination renders obvious “a processing element” as recited in the claim.

[9.4] “receive a plurality of digital data samples derived from the electronic signal”

51. In the combination, Aker discloses that the “function of the digital signal processor 54” (the processing element, *see* [9.3]) “is to ***process...digital samples from channels A and B***” (the electronic signal, *see* [9.1]). ACI-1004, [0049]. Aker discloses that “analog-to-digital converters 48 and 50...sample the analog signals” of channels A and B, and “output these samples as digital sample values on buses 56 and 58 coupled to digital signal processor 54.” *Id.*, [0048]. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.5]: “receive the speed of the patrol vehicle from the speed determining element”

52. In the combination, as previously discussed (*see* [9.2]), Thomas discloses a “controller 10” (the speed determining element) that ***“calculate[s]”*** a ***“current-vehicle-speed signal...from GPS (global positioning data)”*** and outputs the signal to a separate component in its system. ACI-1005, 2:8-10, 4:33-5:16; *see also* 7:7-8:1.

53. Also in the combination, Aker discloses that a “speedometer link transducer 59 ***provides a signal or data to the DSP***” (the processing element, *see* [9.3]) ***from which the indicated speed on the speedometer can be determined*** for use in moving mode target speed calculations.” ACI-1004, [0051].

54. As described above, in the present combination, Aker’s DSP (the processing element, *see* [9.3]) receives the “current-vehicle-speed signal” from Thomas’s controller (the speed determining element, *see* [9.2]) via Aker’s “speedometer link transducer.” *See, e.g.*, ACI-1004, [0051]; ACI-1005, 2:8-10, 4:33-5:16, 7:7-8:1. Further, as described above, a POSITA would have both found this combination of Aker and Thomas to be obvious and been motivated perform the combination.

55. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.6]: “perform a time domain to frequency domain conversion on the digital

data samples creating a plurality of frequency bins, each frequency bin associated with a frequency bin number, having a relative magnitude value, and corresponding to a speed of a vehicle”

56. In the combination, Aker discloses that the “function of the digital signal processor 54 is to *process the digital samples from channels A and B by performing a complex fast Fourier transform on them* to develop an approaching target Fourier spectrum and a receding target Fourier spectrum and then to analyze one or both of these spectrums to determine a target speed and display it.” ACI-1004, [0049]. A Fast Fourier Transform or “FFT” is a mathematical operation that converts a signal in the time domain into a representation in the frequency domain. *See, e.g.*, ACI-1010, [0056]. Thus, the DSP of Aker performs a time domain to frequency domain conversion (a “fast [F]ourier transform”) on the digital data samples. *See* ACI-1004, [0049].

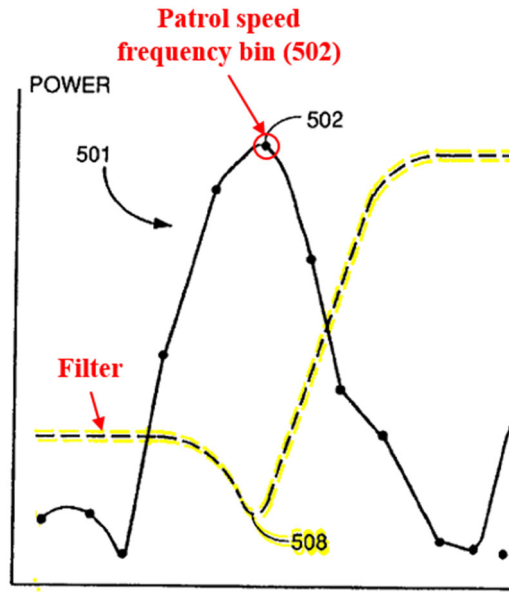
57. Aker further discloses that the fast Fourier transform creates a plurality of “frequency bin[s]” each associated with a “bin number.” *See, e.g.*, ACI-1004, [0091] (“the natural order of both spectra output from the complex FFT is by descending frequency bin”), [0110] (referring to the “top 64 bins” and “the bin number of the candidate”), [0120] (“all bins below the patrol speed but above the strongest target speed”). Aker further discloses that each frequency bin has an “apparent power (relative signal magnitude),” and corresponds to a “relative speed” of a target (*e.g.*, a vehicle) to the patrol speed. ACI-1004, [0115], [0120].

58. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.7]: “convert the speed of the patrol vehicle to a frequency bin number”

59. In the combination, Aker discloses “**determining the speed of the patrol car** either **by means of a link to the speedometer,**” such as the GPS-enabled speedometer of Thomas, “or by acquiring and tracking the patrol car speed from returns from stationary objects as is well known he prior art.” ACI-1004, [0064]. Aker further discloses that the received radar returns are passed “through a digital high pass filter **to remove the patrol speed spectral line therefrom.**” *Id.*, [0103].

60. Also in the combination, Aker ’724 discloses that “[o]nce the patrol speed is determined, **the DSP and its control software effectively filter out the patrol speed return at 502** by superimposing a high pass, high quality elliptical filter response with a zero placed at the center frequency of the patrol speed (the zero is shown graphically at 508) over the FFT calculated spectrum.” ACI-1004, 24:61-67. FIG. 25 of Aker shows a representation of this filtering process:



Aker '724, Detail of FIG. 25 (annotated)

61. As shown in FIG. 25, the frequency bin 502 (which represents the patrol speed) as well as the two adjacent frequency bins (denoted by the two dots next to 502 and contained within the red dashed box annotation) are filtered out by the filter 508. *See* ACI-1007, FIG. 25. In order to set the zero point of the filter 508, the patrol speed is converted into the corresponding frequency bin 502. *See id.*

62. In addition, Aker also discloses an example embodiment where the “patrol car speed is determined from the car's speedometer (as opposed to processing returns from stationary objects such as the ground). . . from which the indicated speed on the speedometer can be determined for use in moving mode target speed calculations.” *Id.*, [0051]. Thus, Aker discloses converting the speed

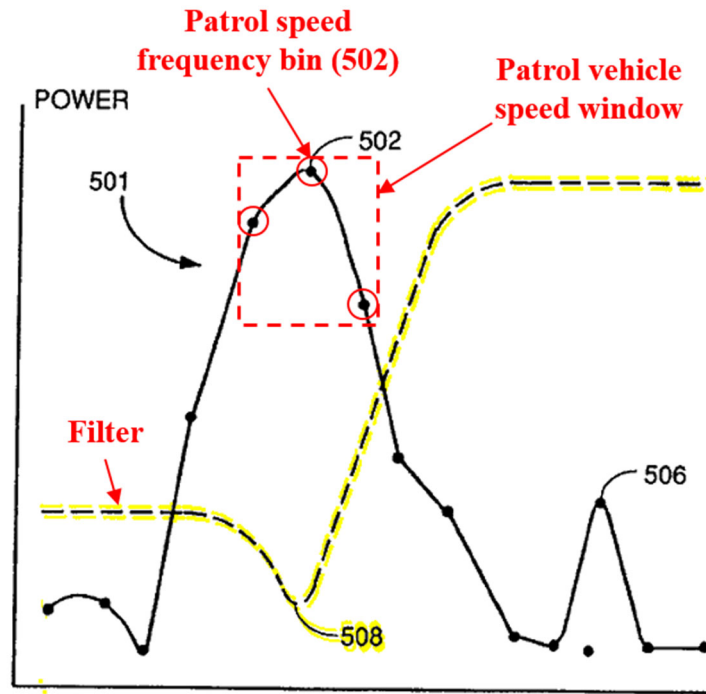
of the patrol vehicle from the speedometer to a frequency bin number instead of from the Doppler radar signal. *Id.*, [0051].

63. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.8]: “form a patrol vehicle speed window that includes a range of frequency bin numbers having the frequency bin number of the converted patrol vehicle speed as a center of the range”

64. In the combination, Aker ’724¹ discloses that “[o]nce the patrol speed is determined, *the DSP and its control software effectively filter out the patrol speed return at 502* by superimposing a high pass, high quality elliptical filter response with a zero placed at the center frequency of the patrol speed (the zero is shown graphically at 508) over the FFT calculated spectrum.” ACI-1007, 24:61-67. FIG. 25 of Aker shows a representation of this filtering process:

¹ Aker details this filtering process (see ACI-1004, [0103]) and notes that the process is described in greater detail in Aker ’724, which, as discussed above, is referenced throughout Aker and which Aker explicitly incorporates by reference. ACI-1004, [0003] (“The Stalker Dual radar is fully described in U.S. Pat. No. 5,691,724 which has an effective filing date of Feb. 10, 1995, the full contents of which are hereby incorporated by reference.”); see also [0052], [0053], [0054], [0084], [0094], [0110].



Aker '724, Detail of FIG. 25 (annotated)

65. As shown in FIG. 25, the frequency bin 502 (which represents the patrol speed) as well as the two adjacent frequency bins (denoted by the two dots next to 502 and contained within the red dashed box annotation) are filtered out by the filter 508. See ACI-1007, FIG. 25. These frequency bins form a patrol vehicle speed window (denoted by the red dashed box annotation) with the frequency bin number of the converted patrol vehicle speed (frequency bin 502) as a center of the range. See ACI-1007, FIG. 25.

66. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.9]: “determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a

spike threshold value”

67. In the combination, Aker discloses a “process of picking the fastest target candidate” from the radar return signals. ACI-1004, [0084]. Aker discloses that “[a]ny known qualification tests on the fastest candidate may be applied, and exhaustive discussion of the fastest target qualification tests used in the Stalker Dual radars in U.S. Pat. No. 5,691,724” (*i.e.*, Aker ’724) “is hereby incorporated by reference and represents a preferred species.” *Id.*

68. Also in the combination, Aker ’724 discloses that “[t]arget identification is performed using an algorithm that *compares the amplitude level of a Fourier component*” (*i.e.*, frequency bin) “which is thought to represent a target return *to the amplitude levels of the Fourier components in the neighborhood* of the selected Fourier component *to determine if a minimum difference exists.*” ACI-1007, 22:1-6. In greater detail, Aker ’724 discloses that “[f]or target processing, *the power of each spectral component, i.e., bin, is compared to the power of some of its neighboring spectral components* to determine if it is a legitimate target return or just noise.” ACI-1007, 23:41-44. “*The power in the selected bin must be 10 db higher than the average power of the 8 neighboring bins to be selected as a target return.*” *Id.*, 23:61-63. Thus, Aker ’724 discloses that the selected bin must have a power (relative magnitude) greater than “the average power of the 8 neighboring bins” (a spike threshold) to

be selected as a target return. *See id.*, 23:41-63; *see also* 48:9-41 (describing a “virtual gauntlet of qualification and disqualification tests that the fastest speed candidate” is subjected to, as shown in “FIGS. 23A-E, 24A-E and 29A-G[.]”).

69. Aker ’724 further discloses that the target frequency bin numbers are outside the patrol vehicle speed window. Aker ’724 discloses that “[o]nce the patrol speed is determined, *the DSP and its control software effectively filter out the patrol speed return at 502* by superimposing a high pass, high quality elliptical filter response with a zero placed at the center frequency of the patrol speed (the zero is shown graphically at 508) over the FFT calculated spectrum.” ACI-1007, 24:61-67. Thus, the target processing described above takes place on the “FFT calculated spectrum” after the frequency bins in the patrol vehicle speed window have been filtered (*e.g.*, zeroed) out, meaning that all of the potential target returns are associated with frequency bins outside the patrol vehicle speed window. *See id.* FIG. 25 of Aker ’724 shows a representation of this filtering process:

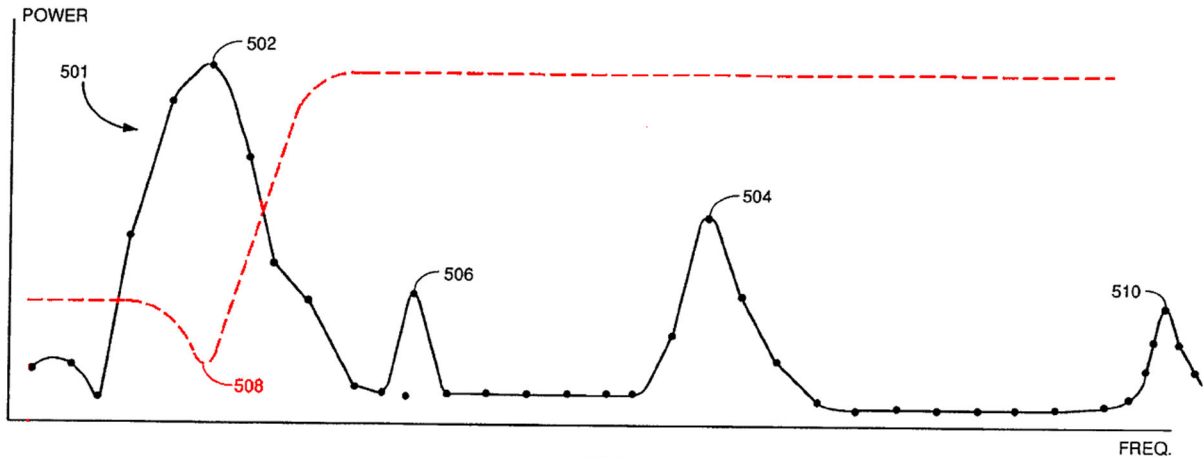


FIG. 25

Aker '724, Detail of FIG. 25 (annotated)

70. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.10]: “convert one frequency bin number in each group to the relative speed of one target vehicle, and”

71. In the combination, Aker '724 discloses that the “spectral components from the FFT analysis” (*i.e.*, the frequency bins) “are then used to calculate...**target speed of the strongest target return**” (*i.e.*, the relative speed of the target vehicle). ACI-1007, 20:30-33.

72. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[9.11]: “convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.”

73. In the combination, Aker discloses that its system “subtracts patrol speed frequency from strongest target frequency and passes the frequency

difference to block 716 where the frequency difference is converted to miles per hour using the relationship that Doppler shift results in a frequency shift of about 103 Hertz per mile per hour.” ACI-1007, 48:4-9; *see also* 10:2-3 (“The speed of the target is derived from subtracting the patrol speed from the target's closing speed.”). The resulting absolute speed value of the target vehicle is then displayed (e.g., by the counting display unit 12). *See id.*, 48:4-9; *see also* 21:44-47.

74. Accordingly, the Aker-Thomas combination renders this limitation obvious.

b) Claim 10

[10.0]: “The traffic radar system of claim 9, wherein the processing element is further configured to perform one of the following depending the directions of travel of the patrol vehicle and the target vehicle:”

75. In the combination, Aker discloses a multimode digital FFT, ***direction sensing, Doppler radar*** where the operator can select between the following modes:

“stationary, strongest only, receding only

stationary, strongest only, approaching only

stationary, fastest only, approaching only

stationary, fastest only, receding only

moving, same lane only, strongest only

moving, same lane only, fastest only

moving, opposite lane only, strongest only

moving, opposite lane only, fastest only.”

ACI-1004, [0017]-[0025].

76. Aker further discloses “*automatically determining whether to add or subtract* the fastest target relative speed from the patrol speed based upon whether the fastest target was found in the approaching target spectrum or the receding target spectrum.” *Id.*, [0073] .

77. Accordingly, the Aker-Thomas combination renders this limitation obvious.

[10.1]: “add the relative speed of the target vehicle to the speed of the patrol vehicle to determine the absolute speed of the target vehicle”

78. Aker discloses “*automatically determining whether to add or subtract* the fastest target relative speed from the patrol speed based upon whether the fastest target was found in the approaching target spectrum or the receding target spectrum.” ACI-1004, [0073].

[10.2]: “subtract the relative speed of the target vehicle from the speed of the patrol vehicle to determine the absolute speed of the target vehicle, and”

79. Aker discloses “*automatically determining whether to add or subtract* the fastest target relative speed from the patrol speed based upon whether the fastest target was found in the approaching target spectrum or the receding target spectrum.” ACI-1004, [0073].

[10.3]: “subtract the speed of the patrol vehicle from the relative speed of the target vehicle to determine the absolute speed of the target vehicle.”

80. Aker discloses that “if the strongest candidate qualifies, step 240 is performed to calculate its speed by taking the candidate's relative speed and ***subtracting from it the patrol speed.***” ACI-1004, [0108].

81. Accordingly, the Aker-Thomas combination renders this limitation obvious.

c) Claim 11

[11.0]: “The traffic radar system of claim 9, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

82. In the combination, Aker discloses that “the DSP carries out a process to implement a multimode radar where ***operator selection of moving or stationary mode...***is also provided.” ACI-1004, [0050]. Accordingly, the DSP determines whether the patrol vehicle is moving or stationary based on the mode selection made by the operator. *See id.*

83. As discussed above, Aker discloses “***automatically determining whether to add or subtract*** the fastest target relative speed from the patrol speed based upon whether the fastest target was found in the approaching target spectrum or the receding target spectrum.” ACI-1004, [0073]. This addition/subtraction of

the patrol is not performed if the unit is in stationary mode (*i.e.*, not moving). *Id.*, [0062] (“The fastest target found is then converted to speed.”), FIG. 7, FIG. 8.

d) Claim 14

[14.0]: “The traffic radar system of claim 9, further comprising a display configured to display a plurality of speeds, and the processing element is further configured to control the display to display the speed of the patrol vehicle and the absolute speed of the target vehicle.”

84. In the combination, Aker discloses that the traffic radar system includes a “[d]isplay 60” that “typically has *three display windows, one for patrol speed in moving modes, one for the strongest target's speed and one for the fastest target's speed.*” ACI-1004, [00050].

85. Accordingly, the Aker-Thomas combination renders this limitation obvious.

e) Claim 1

[1.0]: “A traffic radar system comprising”

86. See [9.0].

[1.1]: “a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle and to generate an electronic signal corresponding to the received radar beam”

87. See [9.1].

[1.1]: “a speed determining element configured to determine and output a speed of the patrol vehicle and not receive signals or data from the patrol vehicle; and”

88. See [9.2]. In the combination, the GPS-enabled speedometer of Thomas (the speed determining element) only provides the “current-vehicle-speed signal” to the DSP of Aker (the processing element), and does not receive any signals or data from the DSP. See, e.g., ACI-1005, 4:33-5:16 (speedometer only “receive[s] a signal from...global positioning satellites”); ACI-1004, [0051], [0099] (the DSP “read[s] the transducer and calculate[s] the patrol speed from data acquired from it”).

[1.3]: “a processing element configured to”

89. See [9.3].

[1.4]: “receive a plurality of digital data samples derived from the electronic signal”

90. See [9.4].

[1.5]: “receive the speed of the patrol vehicle from the speed determining element”

91. See [9.5].

[1.6]: “perform a time domain to frequency domain conversion on the digital data samples creating a plurality of frequency bins, each frequency bin associated with a frequency bin number, having a relative magnitude value, and corresponding to a speed of a vehicle”

92. See [9.6].

[1.7]: “convert the speed of the patrol vehicle to a frequency bin number”

93. See [9.7].

[1.8]: “form a patrol vehicle speed window that includes a range of frequency bin numbers having the frequency bin number of the converted patrol vehicle

speed as a center of the range”

94. See [9.8].

[1.9]: “determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a spike threshold value”

95. See [9.9].

[1.10]: “convert one frequency bin number in each group to the relative speed of one target vehicle, and”

96. See [9.10].

[1.11]: “convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.”

97. See [9.11].

f) Claim 2

[2.0]: “The traffic radar system of claim 1, wherein the processing element is further configured to perform one of the following depending the directions of travel of the patrol vehicle and the target vehicle:”

98. See [10.0].

[2.1]: “add the relative speed of the target vehicle to the speed of the patrol vehicle to determine the absolute speed of the target vehicle”

99. See [10.1].

[2.2]: “subtract the relative speed of the target vehicle from the speed of the patrol vehicle to determine the absolute speed of the target vehicle, and”

100. See [10.2].

[2.3]: “subtract the speed of the patrol vehicle from the relative speed of the target vehicle to determine the absolute speed of the target vehicle.”

101. See [10.3].

g) Claim 3

[3.0]: “The traffic radar system of claim 1, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

102. See [11.0].

h) Claim 6

[6.0]: “The traffic radar system of claim 1, wherein the speed determining element is further configured to receive and process radio frequency signals from a global navigation satellite system.”

103. See [9.2].

i) Claim 7

[7.0]: “The traffic radar system of claim 1, further comprising a display configured to display a plurality of speeds, and the processing element is further configured to control the display to display the speed of the patrol vehicle and the absolute speed of the target vehicle.”

104. See [14.0].

j) Claim 8

[8.0]: “The traffic radar system of claim 1, further comprising an analog to digital converter configured to receive the electronic signal and output the digital data samples.”

105. In the combination, Aker discloses that “the channel A and channel B outputs on lines 40 and 42 are coupled to the inputs of a pair of amplifiers 44 and 46.” ACI-1004, [0046]. “The outputs of the amplifiers are coupled...to the input of ***analog-to-digital converters 48 and 50.***” *Id.*, [0047]. “The function of the A/D converters 48 and 50 is to ***sample the analog signals on lines 51 and 53 and***

output these samples as digital sample values on buses 56 and 58 coupled to digital signal processor 54.” Id., [0048]. Accordingly, the Aker-Thomas combination renders this limitation obvious.

k) Claim 15

[15.0]: “The traffic radar system of claim 9, further comprising an analog to digital converter configured to receive the electronic signal and output the digital data samples.”

106. *See* [8.0].

B. Ground 1B: Claims 3-5 and 11-13 are obvious over Aker, Aker ’724, and Thomas in view of Carmichael

1. The combination of Aker, Aker ’724, Thomas, and Carmichael

107. In the combination, the radar system of the previous Aker-Thomas combination is modified based on the teachings of Carmichael to automatically detect, based on vehicle speed, whether the vehicle is moving or stationary. *See* ACI-1006, claim 9; *see also* [0062].

2. Reasons to combine Aker, Aker ’724, Thomas, and Carmichael

108. It would have been obvious to a POSITA to modify the previous Aker-Thomas combination to automatically detect, based on vehicle speed, whether the vehicle is moving or stationary, as taught by Carmichael. For example, as disclosed in Carmichael, “[f]or ease of operation, it is desirable to have the radar device automatically switch over to stationary mode if the patrol vehicle is

stopped,” and “likewise, *it is also desirable* to have the radar device to switch back to moving mode once the patrol vehicle is moving again.” ACI-1006, [0062]. A POSITA would have been aware of the desirability of these features based on Carmichael’s disclosure, and thus would have been motivated to incorporate the automatic movement detection of Carmichael into the Aker-Thomas combination. *See id.*

109. Further, a POSITA would have found it obvious to modify the previous Aker-Thomas combination based on Carmichael’s teachings because doing so entails the use of known solutions to improve similar systems and methods in the same way. Here, “when a patent ‘simply arranges old elements with each performing the same function it had been known to perform’ and yields no more than one would expect from such an arrangement, the combination is obvious.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized that applying Carmichael’s teachings to augment the Aker-Thomas system would have led to predictable results without significantly altering or hindering the functions performed by the Aker-Thomas system.

110. In fact, a POSITA would have been motivated to incorporate the well-known techniques of Carmichael into the Aker-Thomas system to achieve the predictable benefits described in Carmichael. *See, e.g.*, ACI-1006, [0062]. Indeed, a POSITA would have had a reasonable expectation of success incorporating

Carmichael's teachings into the Aker-Thomas system, because Carmichael discloses a radar device operating in the proposed manner. *See* ACI-1006, [0062].

111. Accordingly, for at least these reasons, augmenting the Aker-Thomas system based on the teachings of Carmichael would have been routine and straightforward to a POSITA, and it would have been clear that such a combination would predictably work and provide the expected results. *Id.*

3. Analysis

a) Claim 11

[11.0]: “The traffic radar system of claim 9, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

112. In the combination, Carmichael discloses a “radar device” having “a moving mode and a stationary mode,” that “automatically switch[es] to the stationary mode if the vehicle speed information indicates that the speed of the vehicle is zero and automatically switch[es] to the moving mode if the vehicle speed information is not zero.” ACI-1006, claim 9; see also [0062]. As described above, a POSITA would have been motivated to incorporate these features into the prior Aker-Thomas combination.

113. As discussed above, Aker discloses “automatically determining whether to add or subtract the fastest target relative speed from the patrol speed based upon whether the fastest target was found in the approaching target spectrum

or the receding target spectrum.” ACI-1004, [0073]. This addition/subtraction of the patrol is not performed if the unit is in stationary mode (*i.e.*, not moving). *Id.*, [0062] (“The fastest target found is then converted to speed.”), FIG. 7, FIG. 8.

114. Accordingly, the Aker-Thomas-Carmichael combination renders this limitation obvious.

b) Claim 12

[12.0]: “The traffic radar system of claim 9, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to”

115. As previously discussed, in the combination, Thomas discloses a “controller 10” (*i.e.*, a speed determining element) that “includes a receiver 12 to *receive a signal from...global positioning satellites.*” ACI-1005, 4:33-5:3. The controller 10 “*calculate[s]*” a “*current-vehicle-speed signal...from GPS (global positioning data).*” *Id.*, 2:8-10; *see also* 7:7-8:1 (“The information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor 22 input.”). In Thomas’s system, the controller 10 outputs the “current-vehicle-speed signal” to a comparator which compares it to a speed limit signal. ACI-1005, 4:33-5:16. Because the current vehicle speed changes with time, Thomas’s controller 10 sends a stream of messages at regular intervals including the current vehicle speed. *See id.* These messages comprise the “current-vehicle-speed signal” described in Thomas. *See id.*

[12.1]: “determine that the patrol vehicle is moving when the patrol vehicle speed is greater than a first threshold value for a predetermined number of successive messages, and”

116. As previously discussed, in the combination, Carmichael discloses a “radar device” having “a moving mode and a stationary mode,” that “automatically switch[es] to the stationary mode if the vehicle speed information indicates that the speed of the vehicle is zero and ***automatically switch[es] to the moving mode if the vehicle speed information is not zero.***” ACI-1006, claim 9; *see also* [0062]. Thus, if the patrol vehicle speed is greater than zero (a first threshold) for a predetermined number of successive messages (*e.g.*, one) the patrol vehicle is determined to be moving. *See id.*

[12.2]: “determine that the patrol vehicle is stationary when the patrol vehicle speed is less than a second threshold value for a predetermined number of successive messages.”

117. As previously discussed, in the combination, Carmichael discloses a “radar device” having “a moving mode and a stationary mode,” that ***“automatically switch[es] to the stationary mode if the vehicle speed information indicates that the speed of the vehicle is zero*** and automatically switch[es] to the moving mode if the vehicle speed information is not zero.” ACI-1006, claim 9; *see also* [0062]. Thus, if the patrol vehicle speed is zero (*i.e.*, less than a positive second threshold) for a pre-determined number of successive messages (*e.g.*, one) the patrol vehicle is determined to be stationary. *See id.*

c) Claim 13

[13.0]: “The traffic radar system of claim 12, wherein the processing element is further configured to set a mode of speed detection to moving when the processing element determines that the patrol vehicle is moving or to stationary when the processing element determines that the patrol vehicle is stationary.”

118. See [11.0].

d) Claim 3

[3.0]: “The traffic radar system of claim 1, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

119. See [11.0].

e) Claim 4

[4.0]: “The traffic radar system of claim 1, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to determine that the patrol vehicle is moving when the patrol vehicle speed is greater than a first threshold value for a predetermined number of successive messages.”

120. See [12.0], [12.1].

f) Claim 5

[5.0]: “The traffic radar system of claim 1, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to determine that the patrol vehicle is stationary when the patrol vehicle speed is less than a second threshold value for a predetermined number of successive messages.”

121. See [12.0], [12.2].

C. Ground 2A: Claims 1-3, 6-11, 14, and 15 are obvious over Shelton in view of Henderson and Thomas

1. Overview of Shelton

122. Shelton discloses a “digital signal processor (DSP) traffic radar utilizing pulses from the patrol vehicle's electronic speedometer to steer the DSP's search of Doppler return information for the patrol vehicle's radar return signal, to improve target identification and minimize inaccuracies.” ACI-1008, Abstract.

2. Overview of Henderson

123. Similar to Shelton, Henderson discloses a “traffic radar [that] processes Doppler return information by analysis of the received frequency spectrum in order to improve target identification and minimize interference and unwanted harmonics.” ACI-1008, Abstract. “Digital signal processing including transformation of the return information into the frequency domain is employed to provide multiple modes of operation including a stationary mode where either the strongest or the fastest Doppler return signal may be selectively recognized, and moving modes for monitoring traffic moving in both the opposite direction and the same direction as the patrol vehicle.” *Id.*

3. The combination of Shelton, Henderson, and Thomas

124. In the combination, the traffic radar system of Shelton is further detailed in the Henderson patent, which Shelton references multiple times. *See, e.g.,* ACI-1008, 1:19-21 (“such a DSP radar is disclosed, for example, in U.S. Pat. No. 5,528,246 to Henderson et al., owned by the assignee herein”), 3:4-12.

125. In addition, in the combination, the traffic radar system disclosed in Shelton and Henderson is modified such that the controller 10 from Thomas (including the GPS receiver 12) provides a “current-vehicle-speed signal” calculated based on the GPS data to the electronic speedometer interface of the DSP in Shelton. ACI-1005, 2:8-10, 4:33-5:16; ACI-1008, 2:44-3:3. Shelton discloses receiving a current vehicle speed from a speedometer, without limitation to any specific type of speedometer and thus is compatible with a GPS speedometer such as that described by Thomas. ACI-1008, 2:44-3:3.

4. Reasons to combine Shelton and Henderson

126. A POSITA examining Shelton would have looked to Henderson for more information on the operation of Shelton’s traffic radar system because Shelton repeatedly and specifically directs the reader to Henderson for just such information. *See, e.g.*, ACI-1008, 1:19-21 (“such a DSP radar is disclosed, for example, in U.S. Pat. No. 5,528,246 to Henderson et al., owned by the assignee herein”), 3:4-12. Although the text of Henderson is not explicitly incorporated by reference into Shelton, a POSITA would nonetheless have been motivated to obtain more information when implementing the traffic radar system described in Shelton, and would have been directed to Henderson by Shelton’s specific instructions. The result of this combination would have been predictable because Shelton and Henderson describe similar traffic radar system, and thus this portion

of the combination involves no material change to the traffic radar system of Shelton.

127. In addition, it would have been obvious to a POSITA to modify the “DSP traffic radar unit” of Shelton based on the teachings of Henderson to include a “rear antenna” in addition to the front-facing “antenna 12,” and to include a “control button” on the “DSP traffic radar unit” to select either the front or rear antenna for monitoring. In the combination, radar signals received by the rear antenna would be processed in the same manner as signals received by the front-facing antenna 12 in Shelton, and only signals from one of the front or rear antenna would be processed at any time based on the control button selection (as taught by Henderson). *See* ACI-1008, 2:20-29; ACI-1009, 4:24-26, 6:7-9, 8:15-17. A POSITA would have been motivated to perform this modification to expand the capabilities of Shelton’s “DSP traffic radar unit” to include determining the speed of targets both in the front and rear area of the patrol vehicle as opposed to only the front area, allowing a greater range of targets to be analyzed without the need to reposition to the patrol vehicle such that the targets are located in the front area. *See* ACI-1008, 2:20-29; ACI-1009, 4:24-26, 6:7-9, 8:15-17. The results of this modification would have been predictable because Henderson teaches a DSP traffic radar unit operating in the proposed manner. *See* ACI-1009, 4:24-26, 6:7-9, 8:15-17.

5. Reasons to combine Shelton/Henderson and Thomas

128. It would have been obvious to a POSITA to modify the Shelton/Henderson radar system to receive current vehicle speed data from a GPS-enabled speedometer, as taught by Thomas. Thomas states that “[t]he information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor input.” ACI-1005, 7:32-8:1. Thomas discloses such sensors as “largely mechanical and tend to be complex and expensive to fit to a vehicle.” *Id.*, 1:12-13. Eliminating such sensors may simplify the vehicle design, leading to a more robust final product. Further, in the event of an issue with the existing speedometer in a vehicle, such as inaccuracy or mechanical issue, a POSITA would have been motivated to incorporate Thomas’ GPS speedometer, which Thomas emphasizes “can be retro-fitted to 99% of cars on the road today.” ACI-1005, 4:30-31.

129. In addition, Thomas stresses the ease with which its GPS speedometer can be incorporated into a vehicle, stating that the “controller 10 of the present invention can be connected to almost any vehicle in the world” (*id.*, 4:15-16), and that “[t]he controller can be retro-fitted to 99% of cars on the road today” with an “[a]verage installation tak[ing] around 3 hours” (*id.*, 4:30-31). While ease of performing a combination does not necessarily represent a motivation for a

POSITA to do so, these quotes make clear that incorporating Thomas's GPS-enabled speedometer would have been accomplished by a POSITA.

130. Further, a POSITA would have found it obvious to modify Shelton/Henderson based on Thomas's teachings because doing so entails the use of known solutions to improve similar systems and methods in the same way. Here, "when a patent 'simply arranges old elements with each performing the same function it had been known to perform' and yields no more than one would expect from such an arrangement, the combination is obvious." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized that applying Thomas's teachings to augment Shelton/Henderson would have led to predictable results without significantly altering or hindering the functions performed by the Shelton/Henderson system.

131. In fact, a POSITA would have been motivated to incorporate the well-known techniques of Thomas into Shelton/Henderson to achieve the predictable benefits described in Thomas. *See, e.g.*, ACI-1005, 1:12-13, 7:32-8:1. Indeed, a POSITA would have had a reasonable expectation of success incorporating Thomas's teachings into Shelton/Henderson, because both Shelton and Thomas discloses a device operating in the proposed manner. ACI-1008, 2:44-3:3; ACI-1005, 1:12-13, 2:8-10, 4:33-5:16, 7:7-8:1.

132. Accordingly, for at least these reasons, augmenting Shelton/Henderson's device based on the teachings of Thomas would have been routine and straightforward to a POSITA, and it would have been clear that such a combination would predictably work and provide the expected results. *Id.*

6. Analysis

a) Claim 9

[9.0]: “A traffic radar system comprising”

133. To the extent the preamble is limiting, the Shelton-Henderson-Thomas combination renders it obvious. For example, in the combination, Shelton discloses a “digital signal processor (DSP) *traffic radar* utilizing pulses from the patrol vehicle's electronic speedometer to steer the DSP's search of Doppler return information for the patrol vehicle's radar return signal, to improve target identification and minimize inaccuracies.” ACI-1008, Abstract. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.1]: “a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle and to generate an electronic signal corresponding to the received radar beam”

134. In the combination, Shelton discloses “a DSP radar unit 10 with *an antenna 12*” (a first radar transceiver) “*for sending*” (*i.e.*, transmitting) “*and receiving radar signals.*” ACI-1008, 2:20-21. Radar signals would include reflected beams and/or scattered reflected signals, depending on the orientation and

properties of the target. *See id.* Shelton discloses that “[i]t should be understood that [the] DSP traffic radar unit transmits a single frequency microwave signal toward moving and stationary targets,” and that a “portion of the microwave signal is reflected by the targets and is received, mixed, and amplified by the receiver section of antenna 12.” *Id.*, 2:24-29. “The signal received is a composite of all signals reflected by the moving and stationary targets.” *Id.*, 2:29-30.

135. Shelton further discloses that “[r]adar return signals received by antenna 12 are converted from analog to digital by A to D converter 14, and input to signal processing system 16 containing a digital signal processor (DSP).” *Id.*, 2:21-24. The analog signal from the antenna 12 converted to digital by the A to D converter 14 is thus a first electronic signal corresponding to the received radar signals. *See id.*, 2:20-24.

136. In its background section, Shelton states that a prior art DSP radar unit “is disclosed, for example, in U.S. Pat. No. 5,528,246 to Henderson et al., owned by the assignee herein.” *Id.*, 1:19-21. U.S. Patent No. 5,528,246 is the Henderson reference (ACI-1009), which, as described above, is a component of the present combination.

137. In the combination, Henderson discloses a “DSP traffic radar unit” to operates similarly to the unit described in Shelton. *Compare* ACI-1008, 2:20-29 with ACI-1009, 8:15-17. Like Shelton, Henderson discloses that “an antenna” on

the radar unit “transmits a microwave carrier and any portion reflected off any surface towards the receive antenna is processed by the DSP” of the unit. ACI-1009, 8:15-17. “Any portion” would include the entire portion, *i.e.* the entire beam. *See id.* Henderson further discloses that its radar unit includes “**front and rear antennas 240 and 242**, respectively, on the patrol vehicle [for] forward or rearward propagation of the transmitted carrier.” *Id.*, 4:24-26. A “[c]ontrol button 284” on the radar unit “**selects either the front or rear antenna** for monitoring traffic to the front or rear of the patrol vehicle.” *Id.*, 6:7-9. Henderson thus indicates that only one of the front and rear antennas may be active at any time. *See id.*

138. As described above, it would have been obvious to a POSITA to modify the “DSP traffic radar unit” of Shelton based on the teachings of Henderson to include a “rear antenna” (a radar transceiver) in addition to the front-facing “antenna 12” (also a radar transceiver), and to include a “control button” on the “DSP traffic radar unit” to select either the front or rear antenna for monitoring. In the combination, radar signals received by the rear antenna would be processed in the same manner as signals received by the front-facing antenna 12 in Shelton. *See* ACI-1008, 2:20-29. Thus, in the combination, “[r]adar return signals received by” the rear antenna “are **converted from analog to digital** by A to D converter 14, and input to signal processing system 16 containing a digital signal processor

(DSP).” *Id.*, 2:21-24. The analog signal from the rear antenna converted to digital by the A to D converter 14 is thus a second electronic signal corresponding to the received radar signals. *See id.*, 2:20-24.

139. A POSITA would have been motivated to perform this modification for at least the reasons discussed above.

140. Under the First Interpretation of this limitation, either the front or rear antennas from the Shelton-Henderson-Thomas device disclose a “radar transceiver configured to transmit and receive radar beams in a front zone...or in a rear zone.” The Shelton-Henderson-Thomas front antenna is configured to transmit and receive in a front zone, and its rear antenna is configured to transmit and receive in a rear zone. *See, e.g.*, ACI-1009, 4:24-26, 8:15-17. Under the First Interpretation, the radar transceiver need only be configured to transmit and receive in either the front zone or the rear zone, so under this interpretation the limitation is satisfied by either of the Shelton-Henderson-Thomas antennas. *See* ACI-1009, 4:24-26, 8:15-17.

141. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.2] “a speed determining element configured to receive and process radio frequency signals from a global navigation satellite system to determine and output a speed of the patrol vehicle; and”

142. In the combination, Thomas discloses a “controller 10” (*i.e.*, a speed determining element) that “includes a receiver 12 to ***receive a signal from...global positioning satellites.***” ACI-1005, 4:33-5:3. The controller 10 “***calculate[s]***” a “***current-vehicle-speed signal...from GPS (global positioning data).***” *Id.*, 2:8-10; *see also* 7:7-8:1 (“The information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor 22 input.”). In Thomas’ system, the controller 10 outputs the “current-vehicle-speed signal” to a comparator which compares it to a speed limit signal. ACI-1005, 4:33-5:16.

143. Also in the combination, Shelton discloses that its system includes an “electronic speedometer 20” that “outputs a certain number of pulses for each mile the patrol vehicle travels.” ACI-1008, 2:44-45. In Shelton, “[t]he electronic speedometer output pulses are interfaced to the DSP in signal processing system 16 by way of a level converter and a Schmitt trigger logic circuit known in the art, to an edge sensitive interrupt pin on the DSP chip[.]” *Id.*, 2:64-3:3. “The DSP calls an interrupt service routine that counts pulses each time a speedometer pulse is received.” *Id.*, 3:2-3.

144. As described above, in the present combination, the controller 10 from Thomas (including the GPS receiver 12) provides a pulse signal representing the current vehicle speed as calculated based on the GPS data to the DSP of Shelton (the processing element, *see* [9.3] below) in the same manner as the “electronic speedometer” described therein. In addition, as described above, a POSITA would have both found the combination obvious and been motivated perform the combination.

145. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.3]: “a processing element configured to”

146. In the combination, Shelton discloses that its radar unit includes a “***digital signal processor (DSP)***” (a processing element) that performs various processing tasks related to target speed determination. *See, e.g.*, ACI-1008, 2:19-34, 2:39-3:3, 3:16-30.

147. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.4] “receive a plurality of digital data samples derived from the electronic signal”

148. As previously discussed, in the combination, Shelton discloses that “[r]adar return signals received by antenna 12 are converted from analog to digital

by A to D converter 14, and input to signal processing system 16 containing a digital signal processor (DSP).” ACI-1008, 2:21-24. A POSITA would have understood that converting a continuous analog signal (such as the radar return signals) into digital format involves sampling the analog signal to produce digital data samples. See, e.g., ACI-1007, 10:28-52 (“In general, the received data at the antenna is sampled at typically 44 kHz and each sample results in a 16-bit serial data word produced by the Analog to Digital Converter.”); ACI-1004, [0048] (“The function of the A/D converters 48 and 50 is to sample the analog signals on lines 51 and 53 and output these samples as digital sample values on buses 56 and 58 coupled to digital signal processor 54.”); ACI-1009, 4:53-64.

149. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.5]: “receive the speed of the patrol vehicle from the speed determining element”

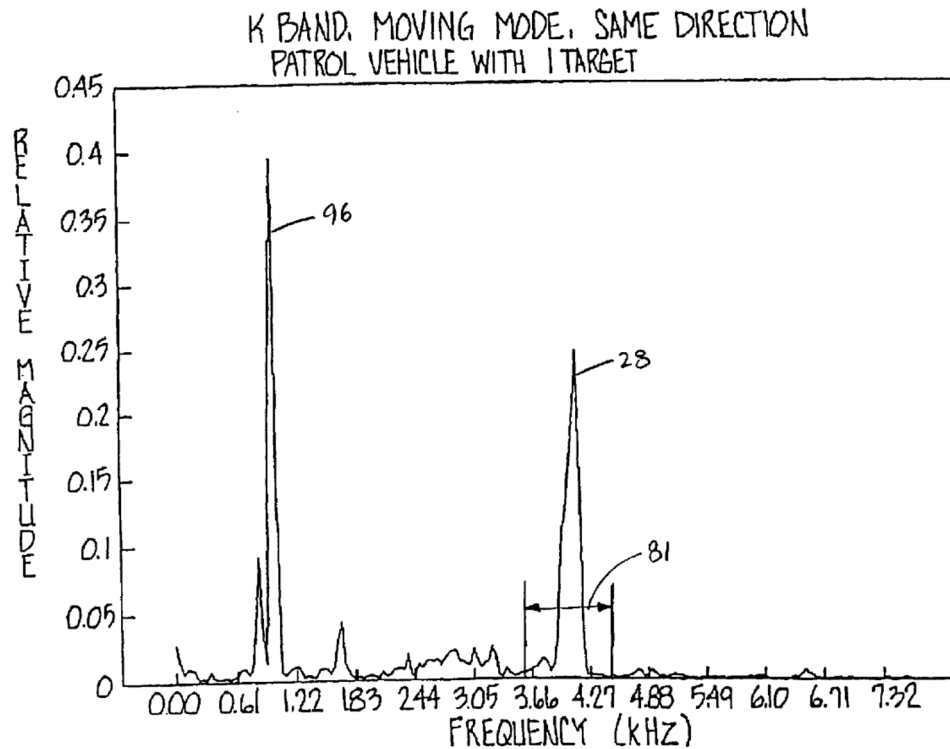
150. In Shelton, “[t]he electronic speedometer output pulses are interfaced to the DSP in signal processing system 16 by way of a level converter and a Schmitt trigger logic circuit known in the art, to an edge sensitive interrupt pin on the DSP chip[.]” *Id.*, 2:64-3:3. “The DSP calls an interrupt service routine that counts pulses each time a speedometer pulse is received.” *Id.*, 3:2-3. “A common value of speedometer pulses is 8,000 pulses per mile,” so “when the patrol vehicle is traveling at a speed of one mile per hour, the speedometer will output (8,000

pulses per mile * 1 mile per hour) pulses per hour.” *Id.*, 2:45-49. Shelton discloses that the DSP calculates the patrol vehicle speed from these pulses. *See id.*, 2:44-3-3.

151. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.6]: “perform a time domain to frequency domain conversion on the digital data samples creating a plurality of frequency bins, each frequency bin associated with a frequency bin number, having a relative magnitude value, and corresponding to a speed of a vehicle”

152. In the combination, Shelton discloses that “*conversion of the signal from the time domain to the frequency domain by the DSP separates the targets by frequency,*” (a plurality of frequency bins) “which is directly proportional to the speed of the target.” ACI-1008, 2:31-34. FIG. 5 from Shelton shows the result of this conversion, in which each frequency bin (shown on the X-axis) is associated with a “relative magnitude” (shown on the Y-axis):

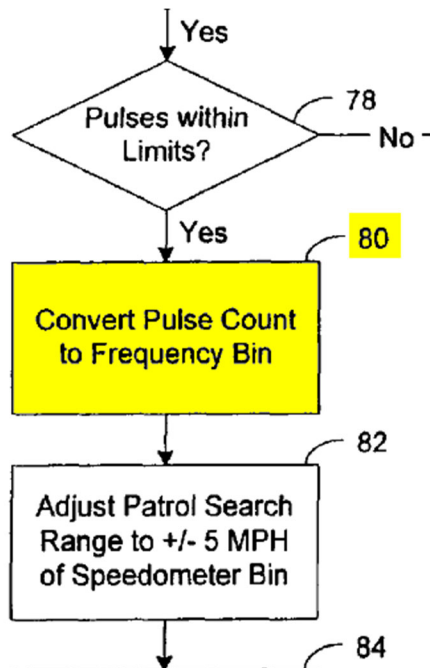


Shelton, Detail of FIG. 5

153. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.7]: “convert the speed of the patrol vehicle to a frequency bin number”

154. In the combination, Shelton discloses that “the operator requests to synchronize the speedometer input to the patrol vehicle radar return 28, which is transformed from the time domain to the frequency domain by the DSP of signal processing system 16.” ACI-1008, 3:16-20. In this way, “the pulse count” from the speedometer “is *converted* from the time domain *to the equivalent bin number* in the frequency domain of the Doppler spectra.” ACI-1008, 4:12-14; *see also* 1:53-58. FIG. 4 from Shelton shows this step:



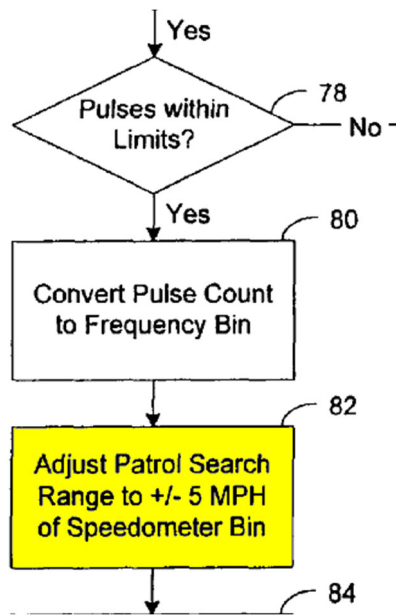
Shelton, Detail of FIG. 4 (annotated)

155. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.8]: “form a patrol vehicle speed window that includes a range of frequency bin numbers having the frequency bin number of the converted patrol vehicle speed as a center of the range”

156. In the combination, Shelton discloses that the “*patrol speed search window 81 is set to plus or minus five MPH (or KPH) of the speedometer bin 82.*” ACI-1008, 1:53-58 (“The signal processing system of the radar unit converts the pulses from the speedometer and calculates the speedometer speed. Using this speed as the center of a search window, the system searches for the patrol vehicle radar return signal that falls within the search window.”); 4:16-18; *see also* claim 1 (“providing a search window around said patrol vehicle speedometer speed, said

window having a lower boundary less than said patrol vehicle speedometer speed and an upper boundary greater than said patrol vehicle speedometer speed.”). FIG. 4 from Shelton shows this step:



Shelton, Detail of FIG. 4 (annotated)

157. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.9]: “determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a spike threshold value”

158. In the combination, Henderson discloses that “[o]nce the patrol speed has been determined, the target vehicle speed may be processed.” ACI-1009, 7:4-5. Henderson discloses several modes of operation for its radar system, including:

“3. Moving mode, opposite direction, strongest signal

4. Moving mode, opposite direction, fastest signal

5. Moving mode, same direction, normal processing

6. Moving mode, same direction, slower target processing.”

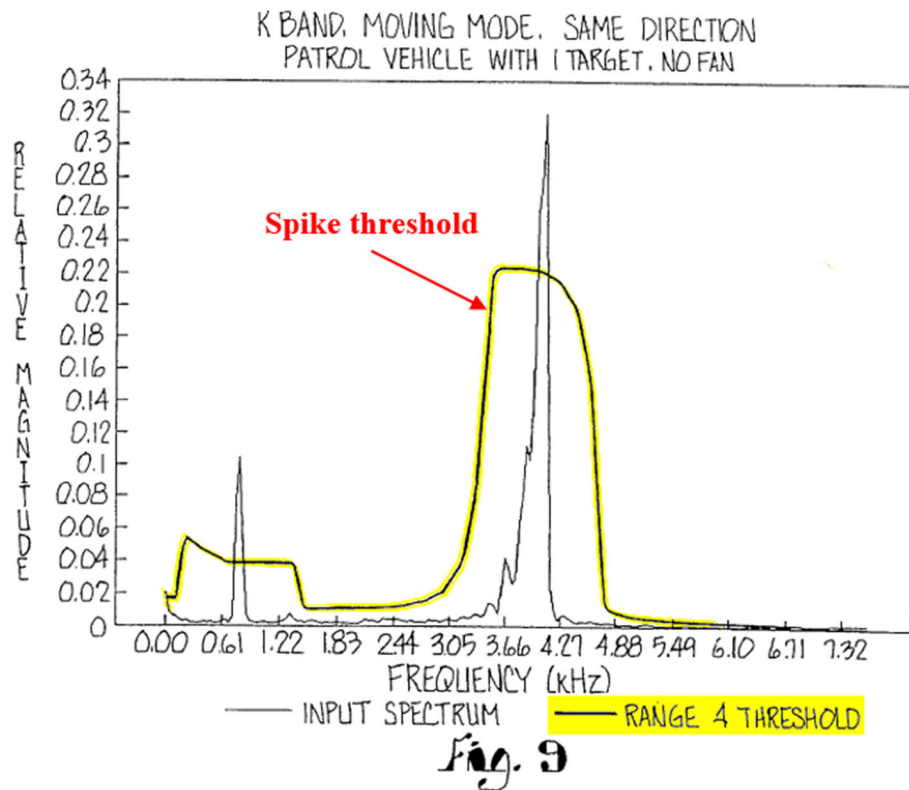
ACI-1009, 5:25-31.

159. Henderson discloses that, in each of these moving modes, the target frequency bin identified will be outside of the patrol speed window. *Id.*, 7:15-17 (Moving mode, opposite direction, strongest signal – “Since this will result in all target vehicle Doppler frequencies being greater than that of the patrol vehicle, the DSP is only required to process those frequencies.”), 7:34-35 (Moving mode, opposite direction, fastest signal – “identical to opposite direction, strongest signal”), 7:47-50 (Moving mode, same direction – “In this case, the target vehicle frequencies may be lower or higher than that of the patrol vehicle depending on target vehicle speed relative to that of the patrol vehicle.”).

160. Further, the target frequency bin must be outside the patrol vehicle speed window in order for the device to accurately identify and determine the speed of targets, because otherwise the patrol speed return could be erroneously identified as a target. *See id.*

161. Also in the combination, Henderson discloses that “[t]he sensitivity of the input spectrum is then gauged by computing a weighted, moving average of the input spectrum as illustrated in FIG. 9 by the **range 4 threshold**” (spike threshold). ACI-1009, 4:65-67. “A frequency peak must be of a greater magnitude than the

weighted, moving average at that frequency in order to be considered valid by the DSP 202.” *Id.*, 5:5-7. FIG. 9 from Henderson shows the spike threshold applied to a set of radar returns in the frequency domain:



ACI-1009, FIG. 9 (annotated)

162. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.10]: “convert one frequency bin number in each group to the relative speed of one target vehicle, and”

163. In the combination, Henderson discloses that “[i]n this case, the Doppler return of the target vehicle will be the frequency shift directly proportional to the speed of the target vehicle added to that of the patrol vehicle. Stated

mathematically: *relative target vehicle frequency = absolute patrol vehicle frequency + absolute target vehicle frequency.*” ACI-1009, 7:7-14. “Therefore, in order to determine the target vehicle frequency, the patrol vehicle frequency must be subtracted from the combined target-patrol frequency.” *Id.*, 7:17-20. “The result is then converted to speed units and sent to the MCU 200.” *Id.*, 7:25-26.

164. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[9.11]: “convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.”

165. In the combination, Henderson discloses multiple different procedures for converting the relative speed of the target vehicle to an absolute speed. The procedures differ depending on the current mode of operation of the radar unit, which can be any of the following:

- “1. Stationary mode, strongest signal
2. Stationary mode, fastest signal
3. Moving mode, opposite direction, strongest signal
4. Moving mode, opposite direction, fastest signal
5. Moving mode, same direction, normal processing
6. Moving mode, same direction, slower target processing.”

166. ACI-1009, 5:25-31. For example, in the “moving mode, opposite direction, strongest signal” mode, Henderson states that “in order to determine the

target vehicle frequency, *the patrol vehicle frequency must be subtracted from the combined target-patrol frequency*...The result is then converted to speed units and sent to the MCU 200.” *Id.*, 7:17-26.

167. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

b) Claim 10

[10.0]: “The traffic radar system of claim 9, wherein the processing element is further configured to perform one of the following depending the directions of travel of the patrol vehicle and the target vehicle:”

168. In the combination, Henderson discloses multiple different modes of operation, including:

- “1. Stationary mode, strongest signal
2. Stationary mode, fastest signal
3. Moving mode, *opposite direction*, strongest signal
4. Moving mode, *opposite direction*, fastest signal
5. Moving mode, *same direction*, normal processing
6. Moving mode, *same direction*, slower target processing.”

ACI-1009, 5:25-31. As shown, these modes specify different directions of patrol of the patrol vehicle and the target vehicle. *See id.*

169. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[10.1]: “add the relative speed of the target vehicle to the speed of the patrol vehicle to determine the absolute speed of the target vehicle”

170. In the combination, Henderson discloses that “[i]n normal same direction (slower patrol speed) the DSP 202 obtains the target vehicle frequency by ***adding the strongest signal's frequency to that of the patrol vehicle.***” ACI-1009, 7:57-59.

171. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[10.2]: “subtract the relative speed of the target vehicle from the speed of the patrol vehicle to determine the absolute speed of the target vehicle, and”

172. In the combination, Henderson discloses that “[i]n slower mode same direction processing (faster patrol speed) the DSP obtains the target vehicle frequency by ***subtracting the strongest signal's frequency from that of the patrol vehicle[.]***” ACI-1009, 7:59-63.

173. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

[10.3]: “subtract the speed of the patrol vehicle from the relative speed of the target vehicle to determine the absolute speed of the target vehicle.”

174. In the “moving mode, opposite direction, strongest signal” mode, Henderson states that “in order to determine the target vehicle frequency, ***the patrol vehicle frequency must be subtracted from the combined target-patrol***

*frequency...*The result is then converted to speed units and sent to the MCU 200.”

ACI-1009, 7:17-26.

175. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

c) Claim 11

[11.0]: “The traffic radar system of claim 9, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

176. In the combination, Shelton discloses that the “operator interface, ***including mode selection*** and data display, is included in logic control system 18.” ACI-1008, 2:35-36. Shelton discloses that “[c]onfiguration and control of a traffic radar unit is typically accomplished using buttons on the front panel of the radar unit and on the remote control unit (as illustrated for example in the U.S. Pat. No. 5,528,246)” which is the Henderson reference. *Id.*, 3:4-7. Henderson discloses that “The modes of operation which may be selected are as follows:

1. ***Stationary mode***, strongest signal
2. ***Stationary mode***, fastest signal
3. ***Moving mode***, opposite direction, strongest signal
4. ***Moving mode***, opposite direction, fastest signal
5. ***Moving mode***, same direction, normal processing

6. ***Moving mode***, same direction, slower target processing.”

177. ACI-1009, 5:23-31. Accordingly, the DSP determines whether the patrol vehicle is moving or stationary based on the mode selection made by the operator. *See id.*

178. Henderson further teaches that selection of stationary mode “configures the DSP 202 to accept all return frequencies as absolute Doppler returns, meaning that the target vehicle's speed is directly proportional to the received frequency,” and thus is not based on the patrol speed. ACI-1009, 6:21-25. By contrast, Henderson teaches that “[w]hen the DSP 202 is placed into the moving mode of operation (blocks 87-90, FIG. 25), the patrol vehicle speed must be determined prior to target speed determination because the antenna is also in motion, thus altering the Doppler frequency shifts of any target vehicle return signals.” ACI-1009, 6:55-59. Thus, the patrol speed is used to determine the absolute target speed only in the moving mode. *See id.*, 6:21-25, 6:55-59.

179. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

d) Claim 14

[14.0]: “The traffic radar system of claim 9, further comprising a display configured to display a plurality of speeds, and the processing element is further configured to control the display to display the speed of the patrol vehicle and the absolute speed of the target vehicle.”

180. In the combination, Henderson discloses the “[t]he digital LED displays illustrated are typical of conventional traffic radar units. *The digital display 204 shows the speed of the target vehicle, display 206 shows the locked target vehicle speed, and display 208 shows the speed of the patrol vehicle when one of the moving modes of operation is selected.*” ACI-1009, 5:37-44.

181. Accordingly, the Shelton-Henderson-Thomas combination renders this limitation obvious.

e) Claim 1

[1.0]: “A traffic radar system comprising”

182. See [9.0].

[1.1]: “a radar transceiver configured to transmit and receive radar beams in a front zone corresponding to an area in front of a patrol vehicle or in a rear zone corresponding to an area behind the patrol vehicle and to generate an electronic signal corresponding to the received radar beam”

183. See [9.1].

[1.1]: “a speed determining element configured to determine and output a speed of the patrol vehicle and not receive signals or data from the patrol vehicle; and”

184. See [9.2].

[1.3]: “a processing element configured to”

185. See [9.3].

[1.4]: “receive a plurality of digital data samples derived from the electronic signal”

186. See [9.4].

[1.5]: “receive the speed of the patrol vehicle from the speed determining element”

187. See [9.5].

[1.6]: “perform a time domain to frequency domain conversion on the digital data samples creating a plurality of frequency bins, each frequency bin associated with a frequency bin number, having a relative magnitude value, and corresponding to a speed of a vehicle”

188. See [9.6].

[1.7]: “convert the speed of the patrol vehicle to a frequency bin number”

189. See [9.7].

[1.8]: “form a patrol vehicle speed window that includes a range of frequency bin numbers having the frequency bin number of the converted patrol vehicle speed as a center of the range”

190. See [9.8].

[1.9]: “determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a spike threshold value”

191. See [9.9].

[1.10]: “convert one frequency bin number in each group to the relative speed of one target vehicle, and”

192. See [9.10].

[1.11]: “convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.”

193. See [9.11].

f) Claim 2

[2.0]: “The traffic radar system of claim 1, wherein the processing element is further configured to perform one of the following depending the directions of

travel of the patrol vehicle and the target vehicle:”

194. See [10.0].

[2.1]: “add the relative speed of the target vehicle to the speed of the patrol vehicle to determine the absolute speed of the target vehicle”

195. See [10.1].

[2.2]: “subtract the relative speed of the target vehicle from the speed of the patrol vehicle to determine the absolute speed of the target vehicle, and”

196. See [10.2].

[2.3]: “subtract the speed of the patrol vehicle from the relative speed of the target vehicle to determine the absolute speed of the target vehicle.”

197. See [10.3].

g) Claim 3

[3.0]: “The traffic radar system of claim 1, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

198. See [11.0].

h) Claim 6

[6.0]: “The traffic radar system of claim 1, wherein the speed determining element is further configured to receive and process radio frequency signals from a global navigation satellite system.”

199. See [9.2].

i) Claim 7

[7.0]: “The traffic radar system of claim 1, further comprising a display configured to display a plurality of speeds, and the processing element is further configured to control the display to display the speed of the patrol vehicle and the

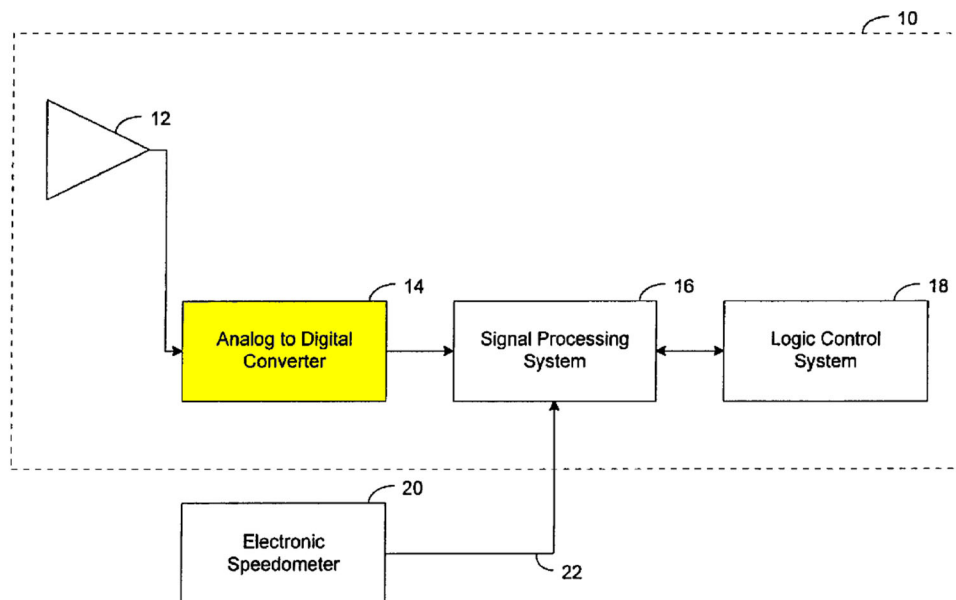
absolute speed of the target vehicle.”

200. See [14.0].

j) Claim 8

[8.0]: “The traffic radar system of claim 1, further comprising an analog to digital converter configured to receive the electronic signal and output the digital data samples.”

201. In the combination, Shelton discloses that “[r]adar return signals received by antenna 12 are converted from analog to digital by A to D converter 14, and input to signal processing system 16.” ACI-1008, 2:21-24; *see also* ACI-1009, 4:8-17, 4:50-53 (describing “conversion” of the radar returns “into digital data by the...analog-to-digital converter (A/D) 224.”). FIG. 1 from Shelton shows the analog to digital converter 14 (annotated in yellow):



Shelton, FIG. 1 (annotated)

k) Claim 15

[15.0]: “The traffic radar system of claim 9, further comprising an analog to digital converter configured to receive the electronic signal and output the digital data samples.”

202. See [8.0].

D. Ground 2B: Claims 3-5 and 11-13 are obvious over Shelton, Henderson and Thomas in view of Carmichael

1. The combination of Shelton, Henderson, Thomas and Carmichael

203. In the combination, the radar system of the previous Shelton-Henderson-Thomas combination is modified based on the teachings of Carmichael to automatically detect, based on vehicle speed, whether the vehicle is moving or stationary. See ACI-1006, claim 9; *see also* [0062].

2. Reasons to combine Shelton, Henderson, Thomas and Carmichael

204. It would have been obvious to a POSITA to modify the previous Shelton-Henderson-Thomas combination to automatically detect, based on vehicle speed, whether the vehicle is moving or stationary, as taught by Carmichael. For example, as described by Carmichael, “[f]or ease of operation, it is desirable to have the radar device automatically switch over to stationary mode if the patrol vehicle is stopped,” and “likewise, *it is also desirable* to have the radar device to switch back to moving mode once the patrol vehicle is moving again.” ACI-1006, [0062]. A POSITA would have been aware of the desirability of these features based on Carmichael’s disclosure, and thus would have been motivated to

incorporate the automatic movement detection of Carmichael into the Shelton-Henderson-Thomas combination. *See id.*

205. Further, a POSITA would have found it obvious to modify the previous Shelton-Henderson-Thomas combination based on Carmichael's teachings because doing so entails the use of known solutions to improve similar systems and methods in the same way. Here, "when a patent 'simply arranges old elements with each performing the same function it had been known to perform' and yields no more than one would expect from such an arrangement, the combination is obvious." *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized that applying Carmichael's teachings to augment the Shelton-Henderson-Thomas system would have led to predictable results without significantly altering or hindering the functions performed by the Shelton-Henderson-Thomas system.

206. In fact, a POSITA would have been motivated to incorporate the well-known techniques of Carmichael into the Shelton-Henderson-Thomas system to achieve the predictable benefits described in Carmichael. *See, e.g.*, ACI-1006, [0062]. Indeed, a POSITA would have had a reasonable expectation of success incorporating Carmichael's teachings into the Shelton-Henderson-Thomas system, because Carmichael discloses a radar device operating in the proposed manner. *See* ACI-1006, [0062].

207. Accordingly, for at least these reasons, augmenting the Shelton-Henderson-Thomas system based on the teachings of Carmichael would have been routine and straightforward to a POSITA, and it would have been clear that such a combination would predictably work and provide the expected results. *Id.*

3. Analysis

a) Claim 11

[11.0]: “The traffic radar system of claim 9, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”

208. In the combination, Carmichael discloses a “radar device” having “a moving mode and a stationary mode,” that “automatically switch[es] to the stationary mode if the vehicle speed information indicates that the speed of the vehicle is zero and automatically switch[es] to the moving mode if the vehicle speed information is not zero.” ACI-1006, claim 9; see also [0062]. As described above, a POSITA would have been motivated to incorporate these features into the prior Shelton-Henderson-Thomas combination.

209. As discussed above, in the combination, Henderson further teaches that selection of stationary mode “configures the DSP 202 to accept all return frequencies as absolute Doppler returns, meaning that the target vehicle's speed is directly proportional to the received frequency,” and thus is not based on the patrol speed. ACI-1009, 6:21-25. By contrast, Henderson teaches that “[w]hen the DSP

202 is placed into the moving mode of operation (blocks 87-90, FIG. 25), the patrol vehicle speed must be determined prior to target speed determination because the antenna is also in motion, thus altering the Doppler frequency shifts of any target vehicle return signals.” ACI-1009, 6:55-59. Thus, the patrol speed is used to determine the absolute target speed only in the moving mode. *See id.*, 6:21-25, 6:55-59.

210. Accordingly, the Shelton-Henderson-Thomas-Carmichael combination renders this limitation obvious.

b) Claim 12

[12.0]: “The traffic radar system of claim 9, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to”

211. As previously discussed, in the combination, Thomas discloses a “controller 10” (*i.e.*, a speed determining element) that “includes a receiver 12 to ***receive a signal from...global positioning satellites.***” ACI-1005, 4:33-5:3. The controller 10 “***calculate[s]***” a “***current-vehicle-speed signal...from GPS (global positioning data).***” *Id.*, 2:8-10; *see also* 7:7-8:1 (“The information available from the GPS system can be used to calculate speed, therefore obviating the need for a separate speed sensor 22 input.”). In Thomas’s system, the controller 10 outputs the “current-vehicle-speed signal” to a comparator which compares it to a speed limit signal. ACI-1005, 4:33-5:16. Because the current vehicle speed changes with

time, Thomas' controller 10 sends a stream of messages at regular intervals including the current vehicle speed. *See id.* These messages comprise the "current-vehicle-speed signal" described in Thomas. *See id.*

212. Accordingly, the Shelton-Henderson-Thomas-Carmichael combination renders this limitation obvious.

[12.1]: "determine that the patrol vehicle is moving when the patrol vehicle speed is greater than a first threshold value for a predetermined number of successive messages, and"

213. As previously discussed, in the combination, Carmichael discloses a "radar device" having "a moving mode and a stationary mode," that "automatically switch[es] to the stationary mode if the vehicle speed information indicates that the speed of the vehicle is zero and ***automatically switch[es] to the moving mode if the vehicle speed information is not zero.***" ACI-1006, claim 9; *see also* [0062]. Thus, if the patrol vehicle speed is greater than zero (a first threshold) for a predetermined number of successive messages (*e.g.*, one) the patrol vehicle is determined to be moving. *See id.*

214. Accordingly, the Shelton-Henderson-Thomas-Carmichael combination renders this limitation obvious.

[12.2]: "determine that the patrol vehicle is stationary when the patrol vehicle speed is less than a second threshold value for a predetermined number of successive messages."

215. As previously discussed, in the combination, Carmichael discloses a “radar device” having “a moving mode and a stationary mode,” that *“automatically switch[es] to the stationary mode if the vehicle speed information indicates that the speed of the vehicle is zero and automatically switch[es] to the moving mode if the vehicle speed information is not zero.”* ACI-1006, claim 9; *see also* [0062]. Thus, if the patrol vehicle speed is zero (*i.e.*, less than a positive second threshold) for a pre-determined number of successive messages (*e.g.*, one) the patrol vehicle is determined to be stationary. *See id.*

216. Accordingly, the Shelton-Henderson-Thomas-Carmichael combination renders this limitation obvious.

c) Claim 13

[13.0]: *“The traffic radar system of claim 12, wherein the processing element is further configured to set a mode of speed detection to moving when the processing element determines that the patrol vehicle is moving or to stationary when the processing element determines that the patrol vehicle is stationary.”*

217. *See* [11.0].

d) Claim 3

[3.0]: *“The traffic radar system of claim 1, wherein the processing element is further configured to determine whether the patrol vehicle is moving or stationary and convert the relative speed of the target vehicle to the absolute speed using the speed of the patrol vehicle only when the patrol vehicle is moving.”*

218. *See* [11.0].

e) Claim 4

[4.0]: “The traffic radar system of claim 1, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to determine that the patrol vehicle is moving when the patrol vehicle speed is greater than a first threshold value for a predetermined number of successive messages.”

219. See [12.0], [12.1].

f) Claim 5

[5.0]: “The traffic radar system of claim 1, wherein the speed determining element outputs the patrol vehicle speed in a stream of messages and the processing element is further configured to determine that the patrol vehicle is stationary when the patrol vehicle speed is less than a second threshold value for a predetermined number of successive messages.”

220. See [12.0], [12.2].

E. Ground 3: Claims 1-15 are obvious over the '039 Publication in view of Jones

1. The '602 Patent is not entitled to its claimed priority date

221. The '039 Patent (ACI-1014) is part of the priority chain of the '602 Patent. ACI-1001, Face. Specifically, the '602 Patent is continuation of U.S. Patent No. 11,579,314, which is a continuation-in-part of the '039 Patent, which claims priority to three provisional applications, the earliest of which was filed on October 9, 2017. *Id.* But, as described below, the specification of the '039 Patent fails to describe all features included in the claims of the '602 Patent. I have been informed that due to this lack of written description support in the '039 Patent's specification, the '602 Patent is not entitled to its claimed priority date.

222. Specifically, if the “radar transceiver” limitation of claims 1 and 9 of the ’602 Patent (Limitations [1.1] and [9.1]) is construed to mean that the radar transceiver (contraction of **transmit** and **receiver**) must be configured to “transmit and receive radar beams” from **both** of the front zone or the rear zone (the Second Interpretation above), then the limitation is not supported by the specification of the ’039 Patent. The ’039 Patent specification does not include any description of a “radar transceiver” that is “configured to transmit and receive radar beams” in both “a front zone corresponding to an area in front of a patrol vehicle” or “in a rear zone corresponding to an area behind the patrol vehicle.” The ’039 Patent instead describes a “front radar transceiver” configured to transmit and receive radar beams only “in front of the patrol vehicle, also known as the ‘front zone’” and a *separate* “rear radar transceiver” configured to transmit and receive radar beams only “in the rear of the patrol vehicle, also known as the ‘rear zone.’” ACI-1014, 4:13-5:8; *see also* FIG. 2 (showing the separate front and rear transceivers 12 and 14 and the areas covered by each). Disclosure of these two separate radar transceivers covering the front and rear zones is insufficient to support claims directed to a single transceiver covering both the front and rear zones under this proposed construction. *See id.*

223. Accordingly, because the ’039 Patent does not support the “radar transceiver” limitation present in all claims of the ’602 Patent, the earliest priority

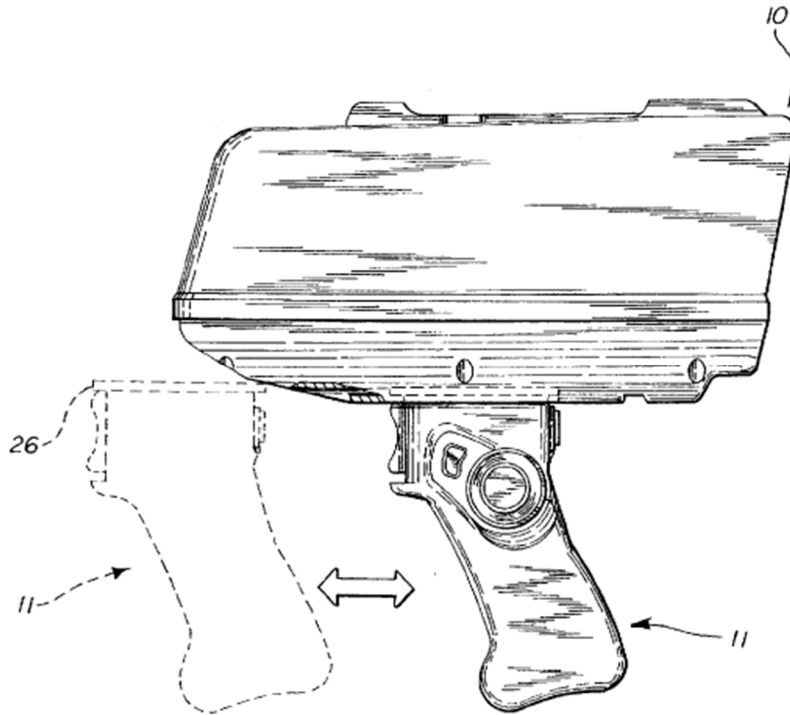
date to which the '602 Patent is entitled is June 21, 2022—the filing date of the '602 Patent and the date on which the new matter was added to the application. ACI-1001, Face.

2. The '039 Publication qualifies as prior art to the '602 Patent

224. The '039 Publication (ACI-1015) is the U.S. Patent Publication of the '039 Patent. *See* ACI-1014, Face. Because, as discussed above, the earliest possible priority date of the '602 Patent is March 9, 2021, I have been informed that the '039 Publication qualifies as prior art to the '602 Patent at least because it was published on April 11, 2019, over three years before the earliest possible priority date of the '602 Patent (June 21, 2022). 35 U.S.C. § 102(a)(1); *see* ACI-1015, Face.

3. Overview of Jones

225. Jones describes a “velocity/speed measurement radar unit” that “incorporates a handle assembly for detachment from a base unit to allow for convertibility from a hand-held unit to a remote controlled radar unit.” ACI-1016, Abstract. FIG. 4 from Jones shows the removable handle assembly 11 used with a traffic radar unit 10:



ACI-1016, Detail of FIG. 4

4. The combination of the '039 Publication and Jones

226. In the combination, the handle assembly of Jones is implemented in the traffic radar system of the '039 Publication such that an operator of the system can aim the radar transceiver towards both the front and the rear of the vehicle, thereby enabling the transceiver to transmit and receive radar beams in both the front and the rear of the vehicle. ACI-1015, [0024], [0026]; ACI-1016, Abstract, 5:65-67.

5. Reasons to combine '039 Publication and Jones

227. It would have been obvious to a POSITA to modify '039 Publication to include the removable handle assembly taught by Jones. Jones teaches, and a

POSITA would have understood, that it was “desirable for observation instruments, such as...speed measurement or vehicular traffic radar guns...to operate in...a hand-held configuration,” as predictable result enabled by implementing Jones’ removable handle assembly. ACI-1016, 1:12-17.

Specifically, providing a removable handle assembly using the disclosure of Jones to allow a user to convert a dash-mounted traffic radar to operate in a directional hand-held configuration would provide numerous advantages over the prior art non-directional dash-mounted units, as discussed in Jones, and give the operator of the unit the ability to aim the otherwise fixed unit at targets located in both the front and the rear of the patrol vehicle, thereby increasing the utility of the traffic radar unit by enabling it to measure the speed of a larger range of targets. ACI-1016, 1:12-17, 1:24-2:28.

228. Further, a POSITA would have found it obvious to modify the ’039 Publication based on Jones’ teachings to provide the claimed directional transceiver because doing so entails the use of known solutions to improve similar systems and methods in the same way. Here, “when a patent ‘simply arranges old elements with each performing the same function it had been known to perform’ and yields no more than one would expect from such an arrangement, the combination is obvious.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007). A POSITA would have recognized that applying Jones’ teachings to augment the

system of the '039 Publication would have led to predictable results of the claimed directional transceiver without significantly altering or hindering the functions performed by the '039 Publication's system.

229. In fact, a POSITA would have been motivated to incorporate the well-known techniques of Jones into the system of the '039 Publication to achieve the predictable benefits of being able to convert a fixed transceiver to a directional transceiver, as described in Jones. *See, e.g.*, ACI-1016, Abstract, 1:12-17, 5:65-67, FIG. 4. Indeed, a POSITA would have had a reasonable expectation of success incorporating Jones' teachings into the system of the '039 Publication, because Jones describes a device operating in the proposed manner. *See* ACI-1016, Abstract, 1:12-17, 5:65-67, FIG. 4.

230. Accordingly, for at least these reasons, augmenting the '039 Publication's device based on the teachings of Jones would have been routine and straightforward to a POSITA, and it would have been clear that such a combination would predictably work and provide the expected results. *Id.*

6. Analysis

a) Claim 9

Limitation [9.0]²

² For the sake of brevity, Ground 3 refers to the Limitation numbers in the Claim Listing table. *See* page iv.

231. The '039 Publication discloses a “traffic radar system.” *See, e.g.*, ACI-1015, Abstract, [0004], [0022], FIGS. 1, 2, claims 1, 10.

Limitation [9.1]

232. In the combination, the '039 Publication discloses that the “traffic radar system” includes a “***radar transceiver***” that “may be mounted or installed on the forward portion of the patrol vehicle, such as a hood, a grill, or a front bumper of the vehicle,” and that produces a “radar beam” that “is transmitted in front of the patrol vehicle.” ACI-1015, [0024], [0026].

233. Also in the combination, Jones discloses “a handle assembly 11 for attachment to and control of a radar base unit 12 for convertibility from a hand-held to a remote radar system.” ACI-1016, 5:65-67. As described above, it would have been obvious to a POSITA to incorporate Jones’ handle assembly into the traffic radar system of the '039 Publication to enable an operator of the system to aim the radar transceiver towards both the front and the rear of the vehicle, thereby enabling the transceiver to transmit and receive radar beams in both the front and the rear of the vehicle.

Limitation [9.2]

234. The '039 Publication discloses a “speed determining element...configured to receive and process radio frequency signals from a global

navigation satellite system to determine and output a speed of the patrol vehicle.”

ACI-1015, [0006], claim 10.

Limitations [9.3]-[9.11]

235. The '039 Publication discloses:

[9.3] a processing element configured to [9.4] receive a plurality of digital data samples derived from the first or second electronic signals, [9.5] receive the speed of the patrol vehicle, [9.6] perform a time domain to frequency domain conversion on the digital data samples creating a plurality of frequency bins, each frequency bin associated with a bin number, having a relative magnitude value, and corresponding to a speed of a vehicle, [9.7] identify a range of frequency bin numbers that correspond to the speed of the patrol vehicle and [9.8] form a patrol vehicle speed window, [9.9] determine at least one group of successive frequency bin numbers outside of the patrol vehicle speed window whose relative magnitude is greater than a spike threshold value, [9.10] convert one frequency bin number in each group to the relative speed of one target vehicle, and [9.11] convert the relative speed of the target vehicle to an absolute speed using the speed of the patrol vehicle.

236. ACI-1015, claim 10 (bracketed numbers added to indicate corresponding limitations).

b) Claim 10

237. Claim 11 of the '039 Publication is textually identical to claim 10.
ACI-1015, claim 11.

c) Claim 11

238. Claim 12 of the '039 Publication is textually identical to claim 11.

ACI-1015, claim 12.

d) Claim 12

239. Claim 13 of the '039 Publication is textually identical to claim 12.

ACI-1015, claim 13.

e) Claim 13

240. *See* [11.0].

f) Claim 14

241. Claim 14 of the '039 Publication is textually identical to claim 14.

ACI-1015, claim 14.

g) Claim 1

Limitations [1.0]-[1.11]

242. *See* [9.0]-[9.11].

h) Claim 2

Limitations [2.0]-[2.3]

243. *See* [10.0]-[10.3].

i) Claim 3

244. *See* [11.0].

j) Claim 4

245. Claim 5 of the '039 Publication is textually identical to claim 4. ACI-1015, claim 5.

k) Claim 5

246. Claim 6 of the '039 Publication is textually identical to claim 5. ACI-1015, claim 6.

l) Claim 6

247. Claim 7 of the '039 Publication is textually identical to claim 6. ACI-1015, claim 7.

m) Claim 7

248. Claim 8 of the '039 Publication is textually identical to claim 7. ACI-1015, claim 9.

n) Claim 8

249. Claim 9 of the '039 Publication is textually identical to claim 8. ACI-1015, claim 9.

o) Claim 15

250. Claim 15 of the '039 Publication is textually identical to claim 15. ACI-1015, claim 15.

V. LEGAL PRINCIPLES

A. Anticipation

251. I have been informed that a patent claim is invalid as anticipated under 35 U.S.C. § 102 if each and every element of a claim, as properly construed,

is found either explicitly or inherently in a single prior art reference. Under the principles of inherency, if the prior art necessarily functions in accordance with, or includes the claimed limitations, it anticipates.

252. I have been informed that a claim is invalid under 35 U.S.C. § 102(a) if the claimed invention was known or used by others in the U.S., or was patented or published anywhere, before the applicant's invention. I further have been informed that a claim is invalid under 35 U.S.C. § 102(b) if the invention was patented or published anywhere, or was in public use, on sale, or offered for sale in this country, more than one year prior to the filing date of the patent application. And a claim is invalid, as I have been informed, under 35 U.S.C. § 102(e), if an invention described by that claim was described in a U.S. patent granted on an application for a patent by another that was filed in the U.S. before the date of invention for such a claim.

B. Obviousness

253. I have been informed that a patent claim is invalid as "obvious" under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a POSITA, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called "secondary considerations" of nonobviousness, which include: (i) "long felt need" for the claimed invention, (ii)

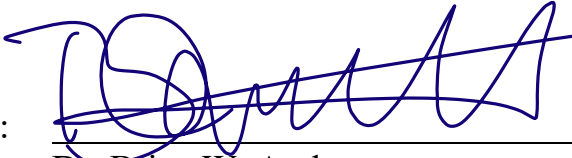
commercial success attributable to the claimed invention, (iii) unexpected results of the claimed invention, and (iv) “copying” of the claimed invention by others.

254. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason to modify the single prior art reference, or combine two or more references, in order to achieve the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, or may come from the reference or references themselves, the knowledge or “common sense” of one skilled in the art, or from the nature of the problem to be solved, and may be explicit or implicit from the prior art as a whole. I have been informed that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

I currently hold the opinions set expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

I hereby declare that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

Dated: 4/30/24

By: 
Dr. Brian W. Anthony

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
School of Engineering Faculty Personnel Record

Date: March 12, 2021

Name:

Brian W. Anthony

Department: Mechanical Engineering / Institute of Medical Engineering and Science

1. Date of Birth: July 1972

2. Citizenship: USA

3. Education:

<u>School</u>	<u>Degree</u>	<u>Date</u>
Carnegie Mellon University	BS	1994
MIT	SM	1998
MIT	PhD	2006

4. Title of Thesis for Most Advanced Degree:
Video Based System Monitoring

5. Principal Fields of Interest:

Biomedical Imaging, Computational Instrumentation, Device Design and Manufacturing,
Innovation and Product Realization, Ultrasound Imaging

6. Name and Rank of Other Department Faculty in the Same Field:

Harry Asada, Professor

Ian Hunter, Professor

Kamal Youcef-Toumi, Professor

7. Non-MIT Experience (including military service):

<u>Employer</u>	<u>Position</u>	<u>Beginning</u>	<u>Ending</u>
LANL	Scientist	1992	1994
Independent Consultant	Consultant	1994	1998
Xcitex	CoFounder / CTO	1998	2005
Cooper Perkins	CTO	2005	2007
dRNome	CoFounder	2011	2016

8. History of MIT Appointments:

<u>Rank</u>	<u>Beginning</u>	<u>Ending</u>
Lecturer, Sloan	2006	2009
Lecturer, MechE	2006	(present)
Research Scientist	2006	2013
Principal Research Scientist	2013	(present)
Director Singapore MIT Alliance – Manufacturing Systems and Technology Program (SMA-MST)	2006	2010
Director Master of Engineering in Manufacturing Program (MEngM)	2006	(present)
Faculty Lead for Education, MIT Skoltech Initiative	2011	2016

Deputy Director, MIT Skoltech Initiative	2014	2016
Associate Director, AIM Academy	2016	2017
Associate Director, MIT.nano	2017	
Faculty Lead for Industry Engagement, MechE	2018	

9. Consulting Record:

Engagements greater than 3 months.

<u>Firm</u>	<u>Beginning</u>	<u>Ending</u>
Los Alamos National Labs		2000
Textron		2000
Federal Trade Commission		2000
FAA		2004
Kodak		2004
Redlake		2005
Olympus		2006
TIS	2009	2012
Photron	2009	2011
Cooper Perkins	2010	2012
IDEO	2012	---
Alcon	2012	---
Ximedica	2013	2014
Herman Miller	2014	2014
Novartis	2015	2015
Lenze	2015	2016
Baxter	2019	2019
Apple	2017	

10. Professional Service

<u>Activity</u>	<u>Beginning</u>	<u>Ending</u>
MEngM Admissions Committee	2006	present
CDO Admissions Committee	2007	2008
Career Fair – SMA in Singapore, Org Chair	2007	2007
Career Fair – SMA/MIT in Singapore, Org Chair	2008	2008
Mfg. microFluidics Symp, Chair	2009	2010
SMART Proposal Lead on Med Devices	3/2010	9/2010
LMP Summit Co-Chair	2011	2011
MEDRC Workshop, Chair	2012	2012
Pilot IMI Proposal, MIT Lead	5/2012	6/2012
Additive mfg working group, Lead	6/2012	8/2012
Co-Chair Education Workstream, AMP 2.0	2013	2014
MIT's role in reducing the cost of health care	2014	2015
AIM Photonics Workforce Committee	2017	2017
Nextflex Collaboration Lead PI	2016	2017
Campus and Community Health Management	2020	2021
MIT-Skoltech Steering Committee	2017	2022
SPIE Conference Committee	2011	2022

MIT / Tufts CTSI TAP Committee
MIT. nano Leadership Council

2020
2017

11. Awards Received:

<u>Award</u>	<u>Date</u>
National Television Academy, Emmy for Innovative Technical Achievement. "Golf on CBS, SwingVision."	2005
BPLA Invented Here, Featured Honoree	2014

12. Current Organization Membership:

<u>Organization</u>	<u>Offices Held</u>
ASME	
IEEE	
SPIE	
AIUM (American Institute of Ultrasound in Medicine)	
Sigma Xi	
RSNA	

13. Patents and Patent Applications Pending:

1. US Patent 5606130 "Method for determining the octane rating of gasoline samples by observing corresponding acoustic resonances therein."
2. US Patent 6393384 "Apparatus and method for remote ultrasonic determination of thin material properties using signal correlation."
3. US Patent 6226081 "Optical height of fill detection system and associated methods."
4. US Patent 8,333,704, B. Anthony and M. Gilbertson, "Handheld Force-Controlled Ultrasound Probe," Dec 11, 2012
5. US Patent 8,328,725, B. Anthony and M. Gilbertson, "Ultrasound Probe," Dec 18, 2012
6. US Patent 8,382,671, B. Anthony and M. Gilbertson, "Handheld Ultrasound Probe," Feb 26, 2013
7. US Patent 9,121,705, B. Anthony and D. Ljubicic, "Sensor for Simultaneous Measurement of Thickness and Lateral Position of a transparent object," Sept 1, 2015
8. US Patent 9,456,800, Brian W. Anthony, Matthew W. Gilbertson, "Ultrasound scanning system", Oct 4, 2016
9. US Patent 10353191, Circular scanning technique for large area inspection, July 16, 2019.
10. MIT Case 14088, Force Controlled Ultrasound Probe, 16-Dec-09
11. MIT Case 14387, Deformation Estimation and Correction in Elastography with a Handheld Force Controlled Ultrasound Probe, 16-Jul-10
12. MIT Case 14422, High-Speed Profilometer for Manufacturing Inspection, 30-Jul-10
13. MIT Case 14966J, Force Measurement Ultrasound Probe for Sonographer Fatigue Monitoring, 10-Jun-11
14. MIT Case 15012, A 6-DOF Optical System for Freehand 3D Ultrasound, 05-Jul-11
15. MIT Case 15681J, Local Actuation and Control of Stamp Deformation in Microcontact Printing, 06-Jun-12
16. MIT Case 15782, Usability Improvements to a Handheld Force-Controlled Ultrasound Probe, 03-Aug-12

17. MIT Case 15884, Computer-Guided Restoration of Ultrasound Scan Poses by Optical Tracking, 01-Oct-12
18. MIT Case 16160, Quick-Release Mechanism for a Force-Measuring Ultrasound Probe, 22-Feb-13
19. MIT Case 16447, Force-correlated Quantitative Ultrasound Image Analysis, 02-Jul-13
20. MIT Case 17106J, Acoustic Characterization of Superficial Body Fluids, 07-May-14
21. MIT Case 17211J, Wireless Capsule Endoscopic Ultrasound, 24-Jun-14
22. MIT Case 17259K, A Concentric Circle Scanning Technique for Large Area Inspection, 09-Jul-14
23. MIT Case 17260K, Grid-Based Matching for Full-Field Large-Area Deformation Measurement, 09-Jul-14
24. MIT Case 17344, Recovery and Computer-Guided Restoration of Ultrasound Scan Poses Based on Human Skin Features, 21-Aug-14
25. MIT Case 17864J, Ultrasound-Based Individual Scatterer Detection Method Using Scatterer Motion Induced by Acoustic Radiation Force, 21-Apr-15
26. MIT Case 17865, Ultrasound-Based Absolute Scatterer Concentration Measurement Technique: Image Volume Estimation from Scatter Spread Function Extracted From the Image, 21-Apr-15
27. MIT Case 17990, Hydrogel Ultrasound Angle Wedge, 04-Jun-15
28. MIT Case 18074, Joint Camera-Ultrasound Data Acquisition for Limb Scanning, 13-Jul-15
29. MIT Case 18544, An Iterative RTM with a Priori Data to Estimate Bone Thickness Using a Cylindrically Scanning Ultrasound Tomography Scanner, 22-Feb-16
30. MIT Case 18545K, Block-Wise Inversion for the Soundspeed of Human Soft Tissue and Bone Using Ray Based Travel Time Tomographic Techniques, 22-Feb-16
31. MIT Case 18636, Concentric Ring-Based Point Pattern Matching of Skin Features, 05-Apr-16
32. MIT Case, Physical and Chemical Characterization of Aerosols with Photonic Waveguides, United States Patent Application 20190234850
33. MIT Case 19192QJ, Non-Invasive Assessment of Venous Pressure via Actuation of Reciprocal Surface Forces for Vessel Collapse Using Single-Crystal Ultrasound in Vertebrates
34. MIT Case 19409, Medical Ultrasound Device with Integrated Force Measurement and Methods for Data Synchronization
35. MIT Case 19460, Shear Wave Elastography Imaging with External Mechanical Vibration
36. MIT Case 19516, Source and Receiver Tracking for Non-Contact Ultrasound
37. MIT Case 19618, Real Time Imaging of Invisible Micron-Scale Monolayer Patterns on a Moving Web Using Condensation Figures
38. MIT Case 19626TE, Apparatus and Methods for Ultrasound Limb Scanning Under Load
39. MIT Case 19710, A Technique for Imaging Cortical Bone and Soft Tissue Using the Level-Set Method to Regularize Travel-Time and Full Waveform Tomography Techniques
40. MIT Case 19791, On chip Photonic Aerosol Spectrometer
41. MIT Case 19921, Equity Disbursement for Bionic Skins LLC (4914743)
42. MIT Case 20289, Miniaturization of External Mechanical Vibration for Ultrasound Shear Wave Elastography Imaging
43. MIT Case 20506L, Systems and Methods for Enabling Non-Contact Laser Ultrasound
44. MIT Case 21078, Microscale Photoacoustic Spectroscopy and Microscopy
45. MIT Case 21123, Tunable Filler Assembly in Multi-material Polymer Extrusions Using Direct Injection and Acoustic Radiation Forces

46. MIT Case 21145, 3D Organ and Tissue Property Mapping using Superficial Vasculature-Based RGBD-SLAM and Deep Vasculature Alignment
47. MIT Case 22420, Integrated Optofluidic Sensor for Thromboembolic and Coagulation Risk Monitoring in COVID-19 Patients at Point-of-Care
48. MIT Case 22432, High Sensitivity and Specificity, Rapid, Low Cost, On-Chip Covid-19 Virus (and Other Virus) Detection using Integrated Photonic Sensors
49. MIT Case 22652, Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning
50. MIT Case 23256, Privacy-Preserving Health Diagnosis of Manufacturing Machines
51. Circular scanning technique for large area imaging (US Patent 10,735,674)
52. Method for detecting circulating cells in superficial body fluids (US Patent 10,639,012)
53. Physical and Chemical Characterization of Aerosols with Photonic Waveguides (US Patent 11,181,454)

14. Professional Registration:

N/A.

15. Major New Products, Processes Designs, or Systems:

See next.

16. Major New Products, Processes Designs, or Systems:

The following is split between a) University Programs or Significant Initiatives, b) Products, and c) Companies.

A. Programs, Centers, or Significant Initiatives

MechE Alliance – Industry Immersion Project Program

The I2P Program provides MechE graduate students with an exclusive opportunity to gain real-world experience working on a 3-to-6 month industry project at a participating company while still enrolled at MIT. Project concepts are first proposed by the company, and then refined and improved by students and their faculty advisors to best suit their academic experience and career interests.

Living Lab in IMES

The Sekisui House at MIT established a multi-year and sustained collaboration around specific themes and needs, answer key questions—via targeted projects designed to collect clinically relevant evidence—and generate significant technology innovations. The program will be staffed and operated by clinicians, researchers, and technical instructors, while fostering educational and global exchange between disparate communities, all while highlighting efforts in medical and observational research. The broader MIT community will be engaged with annual workshops and calls for proposals, as well as nominations for faculty and students to join programs surrounding specific themes.

Immersion Lab – MIT.nano

The Immersion Lab is a two-story, state-of-the-art space for research in visualization, augmented and virtual reality (AR/VR), and the depiction and analysis of spatially related data. Housed in MIT.nano, the lab is an open-access research space. The Immersion Lab mission is to propel research and education at MIT by: Providing the community with an array of cutting-edge technologies to facilitate immersive experiences; Broadening interdisciplinary interest in immersive technologies at MIT and promoting collaborations in art, science, and technology; Supporting teaching in enhanced reality and mentoring MIT community members seeking to realize their projects using our facility; Bridging the domains of hardware and software—and encouraging cycles in which advances in one domain spark innovation in the other; Fueling experimentation and research in enhanced reality technologies through seed grants, shared equipment, symposia, and other resources.

MEngM

Former Director of the Master of Engineering in Manufacturing Program, and previously the director of the Singapore MIT Alliance - Manufacturing Systems and Technology Program since 2006. In these roles I have developed an education partnership program with small to multi-national corporations, defined and built the MEngM program and structure for the development and execution of company-based projects. I place student groups into companies, teach professional engineering practice in the contact of industry based group projects, and broadly define and execute the operations of the MEngM degree program.

MEDRC

Co-Founder, Co-Director of the Medical Electronic Device Realization Center (MEDRC). Along with Charlie Sodini, and Joel Voldman, I recruit large Medical Device manufacturing companies, lead research, and engage with the Med Tech community nationally and internationally.

The MEDRC establishes partnerships between the microelectronics industry, the medical devices industry, medical professionals, and MIT faculty, researchers, and students to collaboratively achieve improvements in the cost and performance of medical electronic devices. The successful realization of such a vision also demands innovations in the usability and productivity of medical devices, and new technologies and approaches to manufacture devices. The MEDRC is a focal point for large business, for venture-funded startups, and for the medical community.

MIT Skoltech Initiative

Deputy Director, and Lead Education, MIT Skoltech Initiative. I served as the education faculty lead in the development of high level curriculum concept for SkolTech Master's degree programs, spanning across domains (space, nuclear, biomedicine, IT, and energy). We develop the education-team collaboration, build consensus on vision, objectives, and plans, and to create education programs for each domain.

MIT.nano / SENSE.nano

Associated Director, MIT.nano. Founding director of first center of excellence at MIT.nano, SENSE.nano.

MIT Center for Clinical and Translation Research

Advisor for Clinical Technology Operation. The CCTR provides the facilities needed to conduct safe human research - in concert with colleagues in MIT Medical, the VPR Office of Research Compliance, and the Committee on the Use of Humans as Experimental Subjects (COUHES). The Center embodies a three-part mission: addressing critical needs in translational research within medicine, expanding central resources essential to MIT, and enabling external links to outside schools (Tufts University, Harvard University, Harvard Medical School), hospitals, and agencies (e.g. FDA).

Other Significant, formative, Initiatives

SMART Center - March through September 2010

I developed consensus around a theme, built the team of 10 investigators in Singapore and 10 investigators at MIT for a whitepaper and requested full center-proposal for SMART, entitled “*Realization (Design, Manufacturing, and Use) of Injectable Physiological Monitors – Enabling a Patient Centric Information Driven Healthcare Future.*”

Pilot Innovation Manufacturing Institute (IMI) Proposal – May, June 2012

A team (University of Massachusetts Amherst, University of Connecticut, Massachusetts Institute of Technology, the Connecticut Center for Advanced Technology, the Pennsylvania State University, UMass Lowell, United Technologies Corporation, and the National Center for Manufacturing Sciences) proposed to form an independent, non-profit technical center of excellence to accelerate technological progress and innovation in additive manufacturing (AM), in response to the May 8, 2012 Air Force Research Laboratory Broad Agency Announcement (BAA-122-17-PKM) for the NNMI pilot.

Flexible Hybrid Electronics Manufacturing Innovation Institute (NextFlex) – October 2015

MIT PI on winning proposal, including a team of Marc Baldo, Duane Boning, Vladimir Bulovic, Karen K Gleason, David E Hardt, Anastasios John Hart, Sang-Gook Kim. \$150M national center with a mission to catalyze the development of an ecosystem for manufacturing new forms of electronics that integrate bulk ICs and printed devices with functions such as power, communications, fluidics, and bio-sensing in flexible systems that can bend, fold, stretch, and conform.

B. Products

Fuselage Crack Inspection System for FAA

In support of the Federal Aviation Administration National Aging Aircraft Research Program (NAARP) the state-of-the-art Full-Scale Aircraft Structural Test Evaluation and Research (FASTER) Facility was established at the FAA William J. Hughes Technical Center - I designed, built, and delivered The Remote-Control Crack Monitoring System consisting of a pair of cameras with two different fields of view manipulative by with a large gantry robot. The cameras ‘fly’ over the fuselage surface to identify and track cracks using processed camera images to generate the feedback signal

Laser Wave for Textron

Textron Inc.’s LaserWave® products integrated advanced signal processing techniques, robust software algorithms, lasers, optics and ultrasonic technology. I developed propagation models describing the propagation of the collapsing circular, thermo-elastic, transient Lamb waves. I developed real-time inversion routines using a time-frequency wavelet decomposition to extract and identify group velocity mode shapes. The LaserWave products use models and algorithms that I developed to invert the measured temporal signals to estimate elastic constants and material thickness of thin layers.

Motion Tools for Photron Inc

I designed Photron Motion Tools to operate high-speed PCI cameras. Photron Motion Tools provides users with manual and automatic tracking capabilities. By simply selecting the point of interest within the recorded image sequence, Motion Tools automatically tracks the points-motion within the sequence.

i-Speed for Olympus

Capable of capturing images at speeds from 60 to 150,000 frames per second in 'normal' mode (down to 1 second/frame in 'timelapse' mode) i-SPEED cameras are an effective method of locating problems quickly and easily. I designed custom software to provide the operator with the ability to analyze and enhance high-speed videos. Velocity and distance measurement can also be calculated. The i-SPEED Software Suite was designed to mirror the ease-of-use and high specification power of the camera range.

Swing Vision for CBS

I designed and built the Swing Vision camera system, camera control system, camera mounts, the server architecture, and the analysis software. Two high-speed cameras record a golfer t-shot. A 2000 fps camera records the full view of the golfer. A 12500 frame per second camera is used to record the ball-club interaction. As the 2000 fps video is broadcast in slow motion, the 12500-fps video (gigabytes of raw video data) is **automatically** analyzed (in under 20 seconds). I won an Emmy for this system in 2005.

MiDAS and ProAnalyst - Xcitex

As Xcitex's CTO and first engineer, I developed the core of the flagship products - MiDAS and ProAnalyst. And as CTO and Vice-President of Xcitex, I developed and directed the development of products and solutions for the industrial and scientific video markets.

C. Companies

Xcitex – CoFounder, formerly CTO, formerly Vice-President, Board of Directors

Xcitex was self-funded and grew through solid product development and consistent execution of our business strategy. As Xcitex's first engineer, I developed the core of the flagship products - MiDAS and Pro Analyst. I also describe these products in a document that I include as supplemental material. As CTO and Vice-President of Xcitex, I built the technical team, architected and directed the development of products and solutions for the industrial and scientific video markets. Our products alone fueled our growth from startup to dominant market leader.

dRNOME – CoFounder, Investor, Board of Director

Provided tools for managing, manipulating, archiving, and searching your scientific video. Removed the necessity for its customers to make heavy investments in expensive hardware and software solutions, removes the overhead required to manage high-volume video needs, and we back this with a service level guarantee.

dRNOME Inc. (CueVue.com – Launched in February 2011, sold technology in 2014). Core technologies used to perform automated feature recognition of multiple streaming telemetry sources and to extract metadata and make this information available for ongoing operations, forensics, and security. Products enable multi-camera real-time feature recognition, extraction & tagging automation.

Enumage – CoFounder, Investor, Board of Director

Specializing in Laser Ultrasound.

1. Books:

Smart Manufacturing On-line course, deployed 2019 and 2020

2. Papers in Referred Journals:

- 2.1. B. Anthony, A. Abbate, D. Klimek, P. Kotidis., "Analysis of Ultrasonic Waves in Arbitrarily Oriented or Rotating Anisotropic Thin Materials", *Quantitative Nondestructive Evaluation*. Vol 18. pgs 215 - 222. (1999).
- 2.2. A. Abbate, B. Anthony, D. Klimek, P. Kotidis., "Analysis of Dispersive Ultrasonic Signals by the Ridges of the Analytic Wavelet Transform", *Quantitative Nondestructive Evaluation*. Vol 18. pgs 703 - 710. (1999).
- 2.3. Dan Klimek, Brian Anthony, Agostino Abbate, Petros Kotidis, "Laser Ultrasonic Instrumentation for Accurate Temperature Measurement of Silicon Wafers in Rapid Thermal Processing Systems", *Rapid Thermal and Integrated Processing VII*, Materials Research Society, Volume 525, pg 135. (1999)
- 2.4. Hardt, D.E., Anthony, B.W., Tor S.B., "A teaching factory for polymer microfabrication - μ Fac," *International Journal of Nanomanufacturing*, 2010, Vol. 6, No.1/2/3/4, pp. 137 - 151.
- 2.5. Shih-Yu Sun, Matthew Gilbertson, and Brian W. Anthony, "Probe Localization for Freehand 3D Ultrasound by Tracking Skin Features", *Book Section, Medical Image Computing and Computer-Assisted Intervention - MICCAI 2014*, Springer, 2014, Vol. 8674. *Lecture Notes in Computer Science*, Pages 365-372.
- 2.6. Xian Du, Brian W. Anthony, Nigel C. Kojimoto, "Grid-based matching for full-field large-area deformation measurement", *Optics and Lasers in Engineering*, Volume 66, March 2015, Pages 307-319.
- 2.7. Xian Du, Nigel C. Kojimoto, Brian W. Anthony, "Concentric circular trajectory sampling for super-resolution and image mosaicing", *Journal of the Optical Society of America A*, Volume 32, No. 2, February 2015, Pages 293-304.
- 2.8. M. Gilbertson, B. Anthony. "A Force and Position Control System for Freehand Ultrasound", *IEEE Transactions on Robotics*, Volume 31, Issue 4. 2015.
- 2.9. Andrey Kuzmin, Aaron Zakrzewski, Brian Anthony, Victor Lempitsky, "Multi-frame Elastography Using Handheld Force-Controlled Ultrasound Probe". *Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, Volume 62, Issue 8, Pages 1486 – 1500, 2015.
- 2.10. Xian Du and Brian Anthony, "Concentric circle scanning system for large-area and high-precision imaging," *Optics Express*, Vol 23, Issue 15, Pages 20014-20029, 2015.
- 2.11. Du, X., Anthony, B., "Controlled angular and radial scanning for super resolution concentric circular imaging," *Opt. Express* 24(20), 22581, United States (2016).
- 2.12. Jimenez, X., Shukla, S. K., Ortega, I., Illana, F. J., Castro-González, C., Marti-Fuster, B., Butterworth, I., Arroyo, M., Anthony, B., et al., "Quantification of Very Low Concentrations of Leukocyte Suspensions In Vitro by High-Frequency Ultrasound," *Ultrasound Med. Biol.* 42(7), 1568–1573, England (2016).
- 2.13. Koppaka, S., Shklyar, I., Rutkove, S. B., Darras, B. T., Anthony, B. W., Zaidman, C. M., Wu, J. S., "Quantitative Ultrasound Assessment of Duchenne Muscular Dystrophy Using Edge Detection Analysis," *J. Ultrasound Med.* 35(9), 1889–1897, United States (2016).
- 2.14. Lee, J., Boning, D., Anthony, B., "Measuring the Absolute Concentration of Microparticles in Suspension using High Frequency B-mode Ultrasound Imaging", *Ultrasound in Medicine and Biology*, 2018.
- 2.15. Correa-de-Araujo, R., Harris-Love, M., Miljkovic, I., Fragala, M.S., Anthony, B.W., Manini, T., Newman, A.B., "The Need for Standardized Assessment of Muscle Quality in Skeletal Muscle Function Deficit and Other Aging-Related Muscle Dysfunctions: A Symposium Report", *Frontiers in Physiology*, Section on Striated Muscle Physiology, 2017

- 2.16 Anthony, B, et al, “A Pilot Study to Precisely Quantify Forces Applied by Sonographers While Scanning: A Step Toward Reducing Ergonomic Injury”, *WORK: A Journal of Prevention, Assessment, and Rehabilitation*, 2017
- 2.17 Zakrzewski, Aaron M., Anthony, Brian W., "Non-Invasive Blood Pressure Estimation Using Ultrasound and Simple Finite Element Models", *IEEE Transactions on Biomedical Engineering*, 2017
- 2.18 Anthony, B., Fitriana, "Computationally-Efficient Optimal Video-Comparison for Machine Monitoring and Process Control", *Journal of Manufacturing Science and Engineering*, 2017
- 2.19 Lee I, Du X, Anthony B. “Hair segmentation using adaptive threshold from edge and branch length measures,” *Computers in Biology Medicine*, (2017).
- 2.20 Pigula-Tresansky AJ, Wu JS, Kapur K, Darras BT, Rutkove SB, Anthony BW. “Muscle compression improves reliability of ultrasound echo intensity,” *Muscle Nerve*, 2017.
- 2.21 Xian Du, David Hardt, and Brian W. Anthony, “Real time imaging of invisible micron-scale monolayer patterns on a moving web using condensation figure,” *IEEE Transactions on Industry Electronics*, (submitted, in review), 2017.
- 2.22 Brian W. Anthony, Xian Du, Ina Kundu, Judith Beaudoin, “Skin registration and point pattern matching of skin microrelief structure,” (submitted, in revision), 2017.
- 2.23 Ozturk A, Grajo JR, Dhyani M, Anthony BW, Samir AE. Principles of ultrasound elastography. *Abdominal Radiology*. 2018.
- 2.24 Benjamin A, Zubajlo RE, Dhyani M, Samir AE, Thomenius KE, Grajo JR, Anthony, Brian W., “A Novel Approach to the Quantification of the Longitudinal Speed of Sound and its Potential for Tissue Characterization (Part I)”, *Journal of Ultrasound in Medicine and Biology*, 2018
- 2.25 B. Anthony et al, “Experimental Validation of Longitudinal Speed of Sound Estimates in the Diagnosis of Hepatic Steatosis (Part II)”, *Journal of Ultrasound in medicine and biology*, 2018
- 2.26 A. Ozturk et al., "Quantitative Hepatic Fat Quantification in NAFLD using Ultrasound-Based Techniques: A Review of Literature and their Diagnostic Performance," *Ultrasound in Medicine and Biology*, 2018
- 2.27 Zakrzewski, A. M., Huang, A. Y., Zubajlo, R. E., & Anthony, B. W. Real-Time Blood Pressure Estimation From Force-Measured Ultrasound. *IEEE Transactions on Biomedical Engineering*, 2018 (Nov 2018 cover article).
- 2.28 Singh, R., Su, P., Kimerling, L., Agarwal, A., & Anthony, B. W. “Towards On-chip Mid Infrared Photonic Aerosol Spectroscopy.” *Applied Physics Letters*. (Accepted). 2018
- 2.29 Ranger, Bryan J., Feigin, M., Zhang, X., Moerman, Kevin M., Herr, H., Anthony, Brian W. “3D ultrasound imaging of residual limbs with camera-based motion compensation”, *Transactions on Neural Systems & Rehabilitation*, (accepted) 2018.
- 2.30 Singh, R., Ma, D., Kimerling, L., Agarwal, A., & Anthony, B. W. “Chemical Characterization of Aerosol Particles Using On-chip Photonic Cavity Enhanced Spectroscopy”. *ACS Sensors*. 2018
- 2.31 Feigin, M., Ranger, B., Anthony, B., “Probabilistic Framework for Maximal Consensus Image Registration with Application to Medical Ultrasound Imaging” *IEEE Transactions on Biomedical Engineering*, (submitted) 2019.
- 2.32 X. Du, D. Hardt, and B. Anthony, “Real Time Imaging of Invisible Micron-Scale Monolayer Patterns on a Moving Web Using Condensation Figures,” *IEEE Trans. Ind. Electron.*, pp. 1–1, 2019.
- 2.33 B. J. Ranger, M. Feigin, X. Zhang, K. M. Moerman, H. Herr, and B. W. Anthony, “3D Ultrasound Imaging of Residual Limbs With Camera-Based Motion Compensation,” *IEEE Trans. Neural Syst. Rehabil. Eng.*, vol. 27, no. 2, pp. 207–217, Feb. 2019.
- 2.34 M. Feigin-Almon, D. Freedman, and B. W. Anthony, “A Deep Learning Framework for Single-Sided Sound Speed Inversion in Medical Ultrasound,” *IEEE Trans. Biomed. Eng.*, pp. 1–1, 2019.
- 2.35 R. Singh, D. Ma, L. Kimerling, A. M. Agarwal, and B. W. Anthony, “Chemical Characterization of Aerosol Particles Using On-Chip Photonic Cavity Enhanced Spectroscopy,” *ACS Sensors*, vol. 4, no. 3, pp. 571–577, Mar. 2019.

- 2.36 Xiang Zhang, Jonathan Fincke, Charles Wynn, Matthew Johnson, Robert Haupt, and Brian Anthony. Full Noncontact Laser Ultrasound: First Human Data. *Nature, Light: Science & Applications*. 2019 (Accepted)
 - 2.37 M. Feigin, M. Zwecker, D. Freedman, and B. W. Anthony, "Detecting muscle activation using ultrasound speed of sound inversion with deep learning," Submitted Oct. 2019.
 - 2.38 S. Kim, D. D. Kim, and B. Anthony, "Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning," Submitted Nov. 2019.
 - 2.39 R. Singh, Y. Nie, A. M. Agarwal, and B. W. Anthony, "Inverse Design of Photonic Metasurface Gratings for Beam Collimation in Opto-fluidic Sensing," Submitted Oct. 2019.
 - 2.40 Benjamin A, Chen M, Li Q, Chen L, Dong Y, Carrascal CA, et al. Renal Volume Estimation Using Freehand Ultrasound Scans: An Ex Vivo Demonstration. *Ultrasound Med Biol*. 2020 Jul;46(7):1769–82.
 - 2.41 Chrzanowski S, Tresansky AP, Nagy J, Rutkove S, Anthony B. Muscle Imaging – MRI. *Neuromuscul Disord*. 2020 Oct;30:S95.
 - 2.42 Singh R, Agarwal A, W Anthony B. Mapping the design space of photonic topological states via deep learning. *Opt Express*. 2020 Sep 14;28(19):27893.
 - 2.43 Lee JH, Traverso G, Ibarra-Zarate D, Boning DS, Anthony BW. Ex Vivo and In Vivo Imaging Study of Ultrasound Capsule Endoscopy. *J Med Device*. 2020 Jun 1;14(2).
 - 2.44 Singh R, Agarwal A, Anthony BW. Design of optical meta-structures with applications to beam engineering using deep learning. *Sci Rep*. 2020 Dec 16;10(1):19923.
 - 2.45 Yang H, Carrascal CA, Xie H, Shamdasani V, Anthony BW. 2-D Ultrasound Shear Wave Elastography With Multi-Sphere-Source External Mechanical Vibration: Preliminary Phantom Results. *Ultrasound Med Biol*. 2020 Sep;46(9):2505–19.
 - 2.46 Benjamin, Alex; Ely, Gregory; Fincke, Jonathan; Anthony BW. Reflection Ultrasound Tomography Using Localized Freehand Scans. *IEEE Int Symp Biomed Imaging*. 2020.
 - 2.47 Ozturk A, Zubajlo RE, Dhyan M, Grajo JR, Mercaldo N, Anthony BW, et al. Variation of Shear Wave Elastography With Preload in the Thyroid: Quantitative Validation. *J Ultrasound Med*. 2021 Apr 20;40(4):779–86.
 - 2.48 Kang HED, Kim D, Kim S, Kim DD, Cheon JH, Anthony BW. Homomorphic Encryption as a secure PHM outsourcing solution for small and medium manufacturing enterprise. *J Manuf Syst*. 2021 Oct;61:856–65.
 - 2.49 Kim S, Kim DD, Anthony B. Dynamic Control of a Fiber Manufacturing Process using Deep Reinforcement Learning. *IEEE/ASME Trans Mechatronics [Internet]*. 2021;4435(c):1–1.
 - 2.50 Fincke J, Zhang X, Shin B, Ely G, Anthony BW. Quantitative Sound Speed Imaging of Cortical Bone and Soft Tissue: Results from Observational Data Sets. *IEEE Trans Med Imaging*. 2021;PP(X):1–1.
 - 2.51 Singh R, Nie Y, Gao M, Agarwal AM, Anthony BW. Inverse design of photonic meta-structure for beam collimation in on-chip sensing. *Sci Rep*. 2021 Dec 5;11(1):5343.
 - 2.52 Benjamin A, Ely G, Anthony BW. 2D speed of sound mapping using a multilook reflection ultrasound tomography framework. *Ultrasonics*. 2021 Jul;114:106393.
3. Proceedings of Refereed Conferences:
- 3.1. Dipen N. Sinha, Brian W. Anthony, David C. Lizon, "Swept Frequency Acoustic Interferometry Techniques for Chemical Weapons Verification and Monitoring", Third International Conference On-Site Analysis, (1995).
 - 3.2. David E. Hardt, Brian W. Anthony and Shu Beng Tor, "A Teaching Factory for Polymer Microfabrication – muFac", Proc. 5th International Symposium on Nano-Manufacturing (ISNM), Athens, November 12-15, 2008.
 - 3.3. Gilbertson, M., Anthony, B., and Sun, S.Y., "Handheld Force Controlled Ultrasound Probe", *J. Med. Devices* 4, 027540 (2010)

- 3.4. Ljubicic, D. M., Anthony, B., "Development of a high-speed profilometer for manufacturing inspection," Proceedings of SPIE Vol. 7767, 776705 (2010).
- 3.5. Sun, S., Anthony, B. W., Gilbertson, M. W., "Trajectory-based deformation correction in ultrasound images," Proceedings of SPIE Vol. 7629, 76290A (2010).
- 3.6. Anthony, B. W., Hardt, D. E., Hale, M., et al., "A research factory for polymer microdevices: muFac," Proceedings of SPIE Vol. 7593, 75930A (2010).
- 3.7. Gilbertson, M. W., Anthony, B. W., "Impedance-controlled ultrasound probe," Proceedings of SPIE Vol. 7968, 796816 (2011).
- 3.8. Ljubicic, D. M., Anthony, B. W., "3D high-speed profilometer for inspection of micro-manufactured transparent parts," Proceedings of SPIE Vol. 8082, 808211 (2011).
- 3.9. Anthony, B.W, Hardt, D.E., "Revitalizing US Manufacturing to Capitalize on Innovation – Through Education" 119th ASEE Annual Conference, San Antonio TX, June 10-13, (2012)
- 3.10. Anthony, B. W., Namvari, K., "Dimensional variation of polymer substrate electrode production," Proceedings of SPIE Vol. 8251, 82510G (2012).
- 3.11. Selvakumar, S., Linares, R., Oppenheimer, A., Anthony, B., "Variation analysis of flow rate delivered using a blister pump," Proceedings of SPIE Vol. 8251, 82510I (2012).
- 3.12. Donoghue, L., Anthony, B. W., "Design for manufacture of a micro-interdigitated electrode for impedance measurement in a biochemical assay," Proceedings of SPIE Vol. 8251, 82510Y (2012).
- 3.13. Holmes, J., Anthony, B. W., "Robustness and repeatability test of interdigitated electrodes on a polymer substrate in an aqueous environment," Proceedings of SPIE Vol. 8251, 825110 (2012).
- 3.14. Sun, S.-Y, Anthony, B. W. "Freehand 3D ultrasound volume imaging using a miniature-mobile 6-DOF camera tracking system". 2012 IEEE International Symposium on Biomedical Imaging (ISBI), 2-5 May, (2012).
- 3.15. Gilbertson, M.W., Anthony, B.A., 2012. "Ergonomic Controls Strategies for a Handheld Force-Controlled Ultrasound Probe," 2012 IEEE/RSJ Intelligent Robots and Systems (IROS) Conference. Vilamoura, Portugal. (2012)
- 3.16. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "6-DoF Probe Tracking via Skin Mapping for Freehand 3D Ultrasound". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).
- 3.17. Sun, S.-Y, Gilbertson, M., Anthony, B. W. "Computer-Guided Ultrasound Probe Realignment by Optical Tracking". 2013 IEEE International Symposium on Biomedical Imaging (ISBI), (2013).
- 3.18. Inamdar, T., Anthony, B. W., "Characterizing fluidic seals for on-board reagent delivery," Proceedings of SPIE (2013).
- 3.19. Zakrzewski, A., Anthony, B. W. "Quantitative Elastography and its Application to Blood Pressure Estimation: Theoretical and Experimental Results". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
- 3.20. Gilbertson, M. Anthony, B.W., "An Ergonomic, Instrumented Ultrasound Probe for 6-Axis Force/Torque Measurement". 2013 IEEE Engineering in Medicine and Biology Society (EMBS), (2013).
- 3.21. Dhyani, M, Gilbertson, M., Samir, A., Anthony, B.W., "Precise Quantification of Sonographic Forces: A First Step Toward Reducing Ergonomic Injury", 2014 AIUM Annual Convention, (2014).
- 3.22. Koppaka, S., Gilbertson, M., Wu, J., Rutkove, S., Anthony, B. W. "Assessing Duchenne Muscular Dystrophy With Force-controlled Ultrasound". 2014 IEEE International Symposium on Biomedical Imaging (ISBI), (2014).
- 3.23. Koppaka, S., Gilbertson, M., Rutkove, S., Anthony, B. W. "Evaluating the Clinical Relevance of Force-correlated Ultrasound". 2014 IEEE International Symposium on Biomedical Imaging (ISBI), (2014).
- 3.24. J. H. Lee, C. M. Schoellhammer, G. Traverso, D. Blankschtein, R. Langer, K. E. Thomenius, D. S. Boning, B. Anthony, "Towards Wireless Capsule Endoscopic Ultrasound (WCEU)," IEEE International Ultrasonics Symposium (IUS), Chicago, IL, 2014, pp. 734-7.

- 3.25. Zhang, Xiang; Fincke, Jonathan; Kuzmin, Andrey; Lempitsky, Victor; Anthony, Brian, "A single element 3D ultrasound tomography system," in Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE , vol., no., pp.5541-5544, 25-29 Aug. 2015.
- 3.26. Ranger, Bryan J.; Feigin, Micha; Pestrov, Nikita; Zhang, Xiang; Lempitsky, Victor; Herr, Hugh M.; Anthony, Brian W., "Motion compensation in a tomographic ultrasound imaging system: Toward volumetric scans of a limb for prosthetic socket design," in Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE , vol., no., pp.7204-7207, 25-29 Aug. 2015.
- 3.27. Lee, John H.; Jimenez, Javier; Xiang Zhang; Boning, Duane S.; Anthony, Brian W., "Ultrasound image-based absolute concentration measurement technique for materials with low scatterer concentration", IEEE International Ultrasonics Symposium (IUS), 2015.
- 3.28. Lee, John H.; Jimenez, Javier; Butterworth, Ian R.; Castro-Gonzalez, Carlos; Shukla, Shiva K.; Marti-Fuster, Berta; Elvira, Luis; Boning, Duane S.; Anthony, Brian W., "Measurement of very low concentration of microparticles in fluid by single particle detection using acoustic radiation force induced particle motion", IEEE International Ultrasonics Symposium (IUS), 2015.
- 3.29. Anthony, B. W., "Enhanced ultrasound for advanced diagnostics, ultrasound tomography for volume limb imaging and prosthetic fitting," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97900Q (2016).
- 3.30. Fincke, J. R., Feigin, M., Prieto, G. A., Zhang, X., Anthony, B., "Towards ultrasound travel time tomography for quantifying human limb geometry and material properties," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97901S (2016).
- 3.31. Kuzmin, A., Zhang, X., Fincke, J., Feigin, M., Anthony, B. W., Lempitsky, V., "Fast low-cost single element ultrasound reflectivity tomography using angular distribution analysis," 2016 IEEE 13th Int. Symp. Biomed. Imaging, 1021–1024, IEEE (2016).
- 3.32. Pigula, A. J., Wu, J. S., Gilbertson, M. W., Darras, B. T., Rutkove, S. B., Anthony, B. W., "Force-controlled ultrasound to measure passive mechanical properties of muscle in Duchenne muscular dystrophy," 2016 38th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., 2865–2868, IEEE (2016).
- 3.33. Ranger, B. J., Feigin, M., Zhang, X., Mireault, A., Raskar, R., Herr, H. M., Anthony, B. W., "3D optical imagery for motion compensation in a limb ultrasound system," Proc. SPIE 9790, N. Duric and B. Heyde, Eds., 97900R (2016).
- 3.34. Zhang, X., Fincke, J. R., Anthony, B. W., "Single element ultrasonic imaging of limb geometry: an in-vivo study with comparison to MRI," Proc. SPIE 9790, 97901R–97901R–7 (2016).
- 3.35. Nguyen, M.M, Graule, M.A., Huang, A.Y, Shamdasani, V., Anthony, B.W., Xie, H., "Ultrasound shearwave elastography with force sensing – integration design and preliminary ex-vivo results.," Proc. Int. Tissue Elast. Conf. 2016 (2016).
- 3.36. Feigin M., Ranger, B., Anthony, B., "Statistical Consensus Matching Framework for Image Registration," IEEE Int. Conf. Pattern Recognition, (2016).
- 3.37. Zakrzewski, A. M., Dhyani, M., Samir, A. E., Anthony, B. W., "Non-Invasive, Non-Occlusive Blood Pressure Estimation Using Ultrasound: Clinical Results (I)," 38th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. (2016).
- 3.38. Anthony, et al, "Arterial Blood Pressure Estimation Using Ultrasound: Results on Healthy Volunteers and a Medicated Hypertensive Volunteer", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., accepted (2017).
- 3.39. Anthony, et al, "Non-Invasive Diagnosis of Non-Alcoholic Fatty Liver Disease (NAFLD) using Ultrasound Image Echogenicity", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., accepted (2017).
- 3.40. Anthony, et al, "Camera-tracking vs. image-based motion compensation in a tomographic limb ultrasound system", 2017 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., (2017).

- 3.41. Fincke JR. Imaging cortical bone using the level-set method to regularize travel-time and full waveform tomography techniques. J Acoust Soc Am. Acoustical Society of America; (2017)
- 3.42. Yang H, Nguyen MM, Huang S-W, Shamdasani V, Xie H, Anthony BW. "Simulation, design, and implementation of external mechanical vibration for ultrasound shear wave elastography.", IEEE International Ultrasonics Symposium (IUS) IEEE; 2017.
- 3.43. A. Benjamin et al., "Non-invasive diagnosis of non-alcoholic fatty liver disease (NAFLD) using ultrasound image echogenicity," 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Seogwipo, 2017,
- 3.44. H. Yang, A. Benjamin, B. Anthony, "Simulation of multi-source external mechanical vibration for shear wave elastography," The Journal of the Acoustical Society of America, 142, 2017
- 3.45. Singh, R., Ma, D., Agarwal, A., & Anthony, B. W. (2018). On-chip photonic particle senso. Presented at the SPIE BiOS, San Francisco, CA.
- 3.46. Kundu, I., & Anthony, B. W. . "Imaging the superficial vascular structure for mapping and identification." ISPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring, Denver, Colorado. (2018)
- 3.47. Kundu, I., Du, X., & Anthony, B. W. (2018). "Imaging platforms for registering and analyzing the skin microrelief structure." Presented at the SPIE Smart Structures and Materials + Nondestructive Evaluation and Health Monitoring, Denver, Colorado. (2018)
- 3.48. Zakrzewski, A. M., & Anthony, B. W. (2018). Pre-and-Post Exercise Blood Pressure Estimation from Force-Measured Ultrasound: First Results. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.
- 3.49. Donk, F., Yang, H., & Anthony, B. W. (2018). Miniaturization of External Mechanical Vibration for Shear Wave Elastography Imaging. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.
- 3.50. Chen, M., Li, Q., Karimian, N., Yeh, H., Duan, Y., Fontan, F., ... Samir, A. E. (2018). Contrast-Enhanced Ultrasound to Quantify Perfusion in a Machine-Perfused Pig Liver. Presented at the 2018 40th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Honolulu, HI.
- 3.51. Wang, Y. J., & Anthony, B. W. (2018). Characterization of wave fields using transient motion of microspheres under acoustic radiation force. Presented at the 21st International Symposium on Nonlinear Acoustics, Santa Fe, NM.
- 3.52. Yang, H., Carrascal, C., Xie, H., Shamdasani, V., Anthony, B.W., "Design and Experimental Validation of Miniature External Mechanical Vibrators towards Clinical Ultrasound Shear Wave Elastography", IUS, 2018.
- 3.53. Singh, Robin; Ma, Danhao; Kimerling, Lionel; Agarwal, Anuradha; Anthony, Brian, "Microscale photoacoustic spectroscopy using integrated photonics for lab-on-chip applications", Spie BIOS, (accepted), 2018.
- 3.54. J. B. Frontin and B. W. Anthony, "Quantifying Dermatology: Method and Device for User-Independent Ultrasound Measurement of Skin Thickness," in 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 5743–5748.
- 3.55. A. Benjamin et al., "Renal volume reconstruction using free-hand ultrasound scans," J. Acoust. Soc. Am., vol. 145, no. 3, pp. 1922–1922, Mar. 2019.
- 3.56. A. Y. Huang and B. W. Anthony, "An Instrumented Ultrasound Probe for Shear Wave Elastography With Uneven Force Distribution," in 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 6208–6211.
- 3.57. Feigin M, Zwecker M, Freedman D, Anthony BW. Detecting muscle activation using ultrasound speed of sound inversion with deep learning. Proc Annu Int Conf IEEE Eng Med Biol Soc EMBS. 2020 Oct 20;2020-July:2092–5.

- 3.58. Li Y, Kim DD, Anthony B. HapticWall - An Ecountered-type Two-Dimensional Vertical System for Virtual Reality. Dyn Syst Control Conf. 2020;1–9.
- 3.59. Feigin M, Zwecker M, Freedman D, Anthony BW. Detecting muscle activation using ultrasound speed of sound inversion with deep learning. In: 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). IEEE; 2020. p. 2092–5.
- 3.60. Feigin M, Makovsky Y, Freedman D, Anthony BW. High-frequency full-waveform inversion with deep learning for seismic and medical ultrasound imaging. In: SEG Technical Program Expanded Abstracts 2020. Society of Exploration Geophysicists; 2020. p. 3492–6.
- 3.61. Singh R, Agarwal A, Anthony BW. Ultra-high sensitive all-optical photoacoustic transducers. In: Oraevsky AA, Wang L V., editors. Photons Plus Ultrasound: Imaging and Sensing 2020. SPIE; 2020. p. 35.
- 3.62. Singh R, Agarwal A, Anthony BW. Leveraging Integrated Photonics for Ultrasound Sensing Applications. In: Imaging and Applied Optics Congress. Washington, D.C.: OSA; 2020. p. JW5A.7.
- 3.63. Singh R, Su P, Agarwal A, Anthony BW. Integrated Mid-IR Photonics for Gas and Aerosol Sensors. In: Imaging and Applied Optics Congress. Washington, D.C.: OSA; 2020. p. JW5C.7.
- 3.64. Ely G, Fincke J, Zhang X, Anthony BW. Optimizing Transducer Acquisition Scheme for Rapid Ultrasound Tomography of Limbs. In: 2020 IEEE International Ultrasonics Symposium (IUS). IEEE; 2020. p. 1–4.
- 3.65. Cuiffi JD, Wang H, Heim J, Anthony BW, Kim S, Kim DD. Factory 4.0 Toolkit for Smart Manufacturing Training. In: 2021 ASEE Virtual Annual Conference Content Access. 2021.
- 3.66. Hahm KS, Chase AS, Dwyer B, Anthony BW. Indoor Human Localization and Gait Analysis using Machine Learning for In-home Health Monitoring. In: 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC). IEEE; 2021. p. 6859–62

4 Articles in Preparation:

- 4.3 Comparison of Quantitative Ultrasound Methods to Classify Pathological Models of Skeletal Muscle, Ultrasound in Medicine and Biology (accepted, 2022)
- 4.4 Homomorphic Encryption Decision Trees for Machine Wear Prediction, Journal of Manufacturing Systems
- 4.5 Ljubicic, D., Anthony, B., "Sensor for Thickness and Lateral Position of a Transparent Web in a Roll-to-Roll Process", target: IEEE Sensors
- 4.6 Automated force-coupled ultrasound method for calibration-free carotid artery blood pressure estimation, UMB,
- 4.7 In-home Health Monitoring using Floor-based Gait Tracking, Journal of Internet of Things, (accepted, 2022)

5. Internal Memoranda and Progress Reports: List chronologically; number each item. N/A

6. Invited Lectures (as of 2015):

- June 2002, "High-speed software synchronizes images and data", Technology Interview. Vision Systems Design.
- June 2003, 2003 "Highspeed Video and Data", Brian W. Anthony, MIT High-Speed Photography and Videography for Motion Analysis: Systems and Techniques.
- June 2003, 2004, 2005, 2006, "Overview of Machine Vision", Brian W. Anthony, MIT High-Speed Photography and Videography for Motion Analysis: Systems and Techniques.
- June 2006, "Video Event Analysis and Video Event Detection - Video Based System Monitoring". Brian W. Anthony. CSAIL Machine Vision Colloquim.

- July 24, 2008, "Computational Imaging Systems," Samsung Electro Mechanical Research, Korea.
- May 5, 2009, "Video Instrumentation," LMP Seminar, MIT
- January 5-7, 2011, "Automation of a Work Cell for Polymer Microdevice Production: Precise Alignment and Visual Quality Inspection ", The Second Conference on Advances in Microfluidics and Nanofluidics and Asian-Pacific International Symposium on Lab on Chip (AMN-APLOC 2011). Singapore.
- February 11, 2011, "The MEDRC," MassMEDIC Board of Directors Meeting. Greenberg Traurig, International Place, Boston.
- March 23-25 2011, "New Perspectives – similar problems", S2I2 Workshop on Collection Digitization, Field Museum, Chicago
- June 20-22, 2011, "Design, Manufacturing, Information Technology, and Healthcare – enabling an information-driven healthcare future – industry, academia collaborations", Medical Device Manufacturing Summit, Red Rock Casino Resort & Spa, Las Vegas, NV.
- July 6, 2011, "Design, Manufacturing, Information Technology, and Healthcare - enabling an information-driven healthcare future – industry, academia collaborations" Korean Institute of Science and Technology.
- Nov 13-15, 2011, Invited Keynote Talk, "Medical Device Manufacturing - Helping to revitalize US manufacturing to capitalize on innovation," Medical Device Manufacturing Summit, Amelia Island, Florida
- November 18, 2011, Invited Keynote Talk, "Computational Videography in Manufacturing," MIT Center for Biomedical Innovation's Biomanufacturing Summit: Implementing Innovation in Biomanufacturing: The Hurdles and Opportunities, Bartos Theater, Building E15 MIT.
- January 27, 2012, "The MEngM and MEDRC Models and Experiences," MassMEDIC's Workshop on Catalyzing Innovation through Industry / Academic Collaborations.
- March 9, 2012, "Computational Enhanced Manufacturing Inspection Systems" Department of Manufacturing Engineering, Ann Arbor, Michigan
- March 13, 2012, "Computational Instrumentation - designing systems at the intersection of mechanical engineering, electrical engineering, and computer science," LMP Seminar, MIT
- March 15-16, 2012, "Industry, innovation, and entrepreneurship, in graduate education and research," SKTech Education Workshop, Moscow, Russia.
- March 27-28 2012, Invited Keynote Talk, "The Inner Beauty of Computational Enhanced Systems," Technology Review EmTech India Conference, Bengaluru, India.
- June 9, 2012, Invited Moderator, "American Transformations: the Next Industrial Revolution", MIT Graduate Alumni - Tech Reunions, MIT, Cambridge, MA.
- May 22 2013, Invited Speaker, MIT Vienna Conference
- June 16, 2013 , Invited Keynote Talk, "Lessons Learned from the MEDRC," EmTech China Conference, Shanghai, China.
- November 13 2013, Invited Speaker, "Microfluidic Devices Manufacturing - Sensing and Instrumentation Challenges and Opportunities", Lab-on-a-chip Asia, Singapore
- October 2013, Invited Speaker, "Have Russia's Innovation Prospects Stalled or Are You Just Not Looking Hard Enough?", US Russian Business Council (USRBC) Annual Meeting,
- January 2015, Keynote, "Limb Imaging" Wayne State University and Karmanos
- January 2015, Philips Research Alliance
- March 2015, Innovation Summit
- April 2015, World Medical Innovation forum
- May 2015, Emtech Columbia
- May 2015, FHE Industry Innovation Summit
- July 2015, ASU Wearables Summit
- August 2015, Medical Systems Design and Development Keynote, EMBC
- September 2015, Novartis Imaging Summit, Basel Switzerland

Publications of Brian W. Anthony

- September 2015, Digital Health, MA Medical Innovation Summit
- October 2015, “Medical Device Innovation”, Novartis Innovation Summit
- November 2015, AIM / FHE / WFD in Chicago
- February 2016, Keynote Talk, Ultrasonic Imaging and Tomography at SPIE Medical Imaging
- April 2016, PMI Aerosol Summit, Switzerland
- April 2016, Body Coupled Communication and interested in wearable ultrasound
- April, 2016 Keynote NIH Muscle Quality, ICSFR Philadelphia
- May 2016, Monterrey Tec-MIT Summit
- June 2016, Polytechnic University of Madrid, Medical Device Keynote
- August, 2016, NIBIB US/India Workshop on Developing Passive, Cuffless, and Noninvasive Blood Pressure Measurement Technologies, Orlando, FL
- August 2016, FNIH Liver Imaging standards workshop, Keynote
- December 2016, Lowell UMass Wearable Sensor Keynote
- March 2017, AUB Conference, Keynote, Beirut
- July 2017, Embc Keynote
- September 2017, National Academies of Sciences, Engineering, and Medicine, DC. Graduate Education in Manufacturing
- September 2017, Health Sensing Conference Keynote
- December 2017, Innovation in Liver Health, Broad
- February 2018, DARPA Innovation in Sensors for Agriculture, Keynote
- May 2018, Siemens Smart Manufacturing Keynote
- Jul 2018, EMBC Imaging Panel
- October 2018, Bloomberg Live Event in Atlanta – Devices and Manufacturing Keynote
- February 2019, 123sonography Live, Ultrasound Innovation, Keynote
- May 2019, Siemens Smart Manufacturing Keynote
- July 2019, Hacking NanoMedicine
- September 2019, Madrid
- October 2019, Lam Research Symposium – Keynote
- January 2020, Consumer Electronics Show (CES) Ambient Sensing, Special Keynote
- February 2020, Wisconsin Workforce Development, Keynote in Smart Manufacturing
- March 2020, Siemens – Keynote on MiA
- May 2020, IMA Innovation in Digital Manufacturing Keynote
- August 2020, High Value Manufacturing Summit (virtual), Keynote
- May 2021, NCSoft mini-workshop Chair
- April 2021, EmTech NEXT's Inside Track: Ambient Sensing
- May 2021, Tufts CTSI Translational Research Day, Keynote
- February 2021, NSF IMSI Keynote - Private AI

Theses Supervised by Brian W. Anthony

Summary:

	<u>Total</u>	<u>Completed</u>	<u>In Progress</u>
Bachelor's	5	5	0
Master's	42	35	7
MEng	29	17	12
Engineer's			
<u>Doctoral</u>			
As Supervisor	26	15	11
As Reader	4	3	1

Last	First	Title	Department	Year	
Bachelor's Theses					
Syverud	Brian	<i>Robotic ultrasound manipulator: calibration of position and orientation measurement system</i>	MechE	2009	
Johnson	Michael	<i>Design of a precise X-Y-Theta nanopositioning optical sensor</i>	MechE	2009	
Chai	Lauren	<i>Design of mechanical arterial simulator</i>	MechE	2012	
Ramos	Javier	<i>Design of Force Measurement Probe</i>	MechE	2012	
Mireault	Alfred Norman	<i>Mechanical design of an ultrasonic tomographic imaging system</i>	MechE	2016	

Master's Theses					
Fitriani		<i>Multiscale Dynamic Time and Space Warping</i>	CDO	2008	
Zarrouati	Nadège	<i>A precision manipulation system for polymer microdevice production</i>	MechE	2010	
Gilbertson	Matthew Wright	<i>Handheld force-controlled ultrasound probe</i>	MechE	2010	
Sun	Shih-Yu	<i>Deformation correction in ultrasound imaging in an elastography framework</i>	EECS	2010	
Zakrzewski	Aaron	<i>Multi-scale quantitative elastography and its application to blood pressure estimation</i>	MechE	2013	
Koppaka	Sisir	<i>Imaging Biomarkers for Duchenne Muscular Dystrophy</i>	CDO	2015	
Zhang	Xiang (Shawn)	<i>Design of a single element 3D ultrasound scanner</i>	MechE	2015	
Primack	Willow	<i>Analysis and Productivity Improvement of an Automated Material Handling System through Simulation</i>	LGO	2015	
Churchill	Hugh E.	<i>Cycle-time Analysis and Improvement Using Lean Methods within a Retail Distribution Center</i>	LGO	2015	

Theses Supervised by Brian W. Anthony

Sazdanoff	Nicholas	<i>Evaluation of postponement in the Drug Product supply chain</i>	LGO	2015	
Kojimoto	Nigel Costello	<i>Ultrasonic inspection methods for defect detection and process control in roll-to-roll flexible electronics manufacturing</i>	MechE	2015	
Kundu	Ina Annesha	<i>Imaging platforms for detecting and analyzing skin features and Its stability : with applications in skin health and in using the skin as a body-relative position-encoding system</i>	MechE	2015	
Conover	Susan	<i>Imaging platforms for detecting and analyzing skin features and Its stability : with applications in skin health and in using the skin as a body-relative position-encoding system</i>	SDM	2015	
Hess	Tylor	<i>Algorithm deployment platform</i>	MechE	2016	
Lee	Kang Qi lan	<i>Computational tools for enabling longitudinal skin image analysis</i>	CDO	2016	
Huang	Athena Yeh	<i>May the force be with you : a medical ultrasound system with integrated force measurement</i>	MechE	2017	
Benjamin	Alex	<i>The (travel) times they are a changing : a computational framework for the diagnosis of non-alcoholic fatty liver disease (NAFLD)</i>	CDO	2017	
Yang	Heng	<i>Ultrasound shear wave elastography imaging with external mechanical vibration</i>	MechE	2017	
Zubajlo	Rebecca	<i>Quantitative biomarkers for tissue characterization</i>	MechE	2017	
Benjamin	Rishon Robert	<i>Silence of the lamb waves</i>	CDO	2017	
Haidar	Samer	<i>Supply chain network strategy for consumer medical device introduction</i>	LGO	2016	
Al-Meer	Mariam	<i>Reducing heart failure admissions through improved care systems and processes</i>	LGO	2017	
Sandford	Michael	<i>Application of 3D printing in medical devices New Product Development</i>	LGO	2017	
Graule	Moritz Alexander	<i>Towards force-correlated ultrasound volume elastography</i>	MechE	2017	
Sun	Mingxiu	<i>Education and practice factory : from factory design to first product delivery</i>	MechE	2018	
Singh	Robin	<i>Whispering photons : on-chip biophotonic integrated circuits for point-of-care diagnostics</i>	MechE	2018	
Beaudoin	Judy	<i>Quantifying dermatology : method and device for user-</i>	MechE	2018	

Theses Supervised by Brian W. Anthony

		<i>independent ultrasound measurement of skin thickness</i>			
DiAndreth	Chris	<i>Optimization of Downstream Supply Chain Product Flow based on an Integrated Cost-to-Deliver Perspective</i>	LGO	2019	
Puppo	Manuel Martinez	<i>Replenishment in an integrated stock world</i>	LGO	2019	
Lu	Shirley Suet-Ning	<i>Design of dynamically controlled desktop fiber accumulator with tension feedback as part of smart manufacturing educational kit</i>	MechE	2020	
Kim	Sangwoon	<i>Model-free tracking control of an optical fiber drawing process using deep reinforcement learning</i>	MechE	2020	
Chen	Hongling (Holly)	<i>Vascular Imaging System for Longitudinal Registration and Mapping of Superficial Vessels with Quantitative Analysis</i>	IDM	2020	
Chavez	Yasmin	<i>System identification and control of a miniature external mechanical vibration device towards clinical ultrasound shear wave elastography</i>	MechE	2020	
Koeppen	Ryan	<i>Design of Electromechanical Attachments for Improved Ultrasound Imaging Repeatability</i>	MechE	2021	
Goryachev	Ivan	<i>Kiosks for Non-Contact Vital Sign Detection</i>	MechE	2021	
Adiwijaya	Zenia	<i>Tenative: ML for Process control</i>	SDM	2023	expected
Chen	George	<i>Tenative: ML for Process control</i>	MechE	2022	expected
Deshpande	Aniruddha	<i>Tenative: Food manufacturing - ML models</i>	EECS	2023	expected
Dhar	Shreya	<i>Tenative: Education Kit</i>	MechE	2023	expected
Espinoza	Victor Reyes	<i>Tenative: ML for Process control</i>	EECS	2022	expected
Justiniano	Eugenio Caraballo	<i>Tenative: Sound and Light on Cells</i>	MechE	2023	expected
Magana-Salgado	Uriel	<i>Tenative: Muscle Health monitoring</i>	MechE	2023	expected

Master Eng. Theses

Su	Xiangyong	<i>Optimization of labor allocation at a syringe production facility : design proposals</i>	MechE	2008	
Liaw	Sze Sen	<i>Optimization of labor allocation at a syringe production facility using computer simulation</i>	MechE	2008	
Ng	Gar Yan	<i>Optimization of labor allocation at a syringe production facility : work study</i>	MechE	2008	

Theses Supervised by Brian W. Anthony

Linares	Rodrigo	<i>Manufacturability of lab on a chip devices: tolerance analysis and requirements establishment</i>	MechE	2010	
Selvakumar	Sivesh	<i>Manufacturing of Lab-On-a-Chip devices : variation analysis of liquid delivery using blister packs</i>	MechE	2010	
Namvari	Kasra	<i>Manufacturability of lab-on-chip devices : dimensional variation analysis of electrode foils using visual technology</i>	MechE	2011	
Donoghue	Linda	<i>Design of a micro-interdigitated electrode for impedance measurement performance in a biochemical assay</i>	MechE	2011	
Holmes	Jacklyn	<i>Robustness and repeatability of interdigitated electrodes on a substrate tested in an aqueous environment</i>	MechE	2011	
Judge	Benjamin	<i>Thermoplastic bonding of microfluidic substrates</i>	MechE	2012	
Jain	Nikhil	<i>A comprehensive study and validation of high-throughput microscale electrode production using thermal transfer printing techniques</i>	MechE	2012	
Inamdar	Tejas Satish	<i>Manufacturing of lab-on-a-chip devices : characterizing seals for on-board reagent delivery</i>	MechE	2013	
Saber	Aabed Saud	<i>Manufacturability of lab on chip devices : reagent-filled reservoirs bonding process and its effect on reagents flow pattern</i>	MechE	2013	
Nguyen	Khanh Huy	<i>Hot embossing as a method for rapid prototyping microfluidic devices</i>	MechE	2013	
Ragosta	Nicholas Hiroshi	<i>Design and measurement analysis of hot embossing system for high aspect ratio microfluidics</i>	MechE	2013	
Kalsekar	Viren Sunil	<i>Design and process optimization of a hot embossing machine for microfluidics with high aspect ratios</i>	MechE	2013	
Xue	Elise	<i>Sensorless ultrasound probe 6DoF pose estimation through the use of CNNs on image data</i>	EECS	2018	
DiAndreth	Christopher	<i>Optimization of downstream supply chain product flow based on an integrated cost-to-deliver perspective</i>	LGO	2019	
Cherna	Samuel	<i>External virbarion on Butterfly Probes</i>	EECS	2022	expected
Sawant	Nilay Sanjay	<i>Tenative: ML for Process Control</i>	MechE	2022	expected
Othman	Mohamed Ayman Mohamed	<i>Tenative: ML for Process Control</i>	MechE	2022	expected

Theses Supervised by Brian W. Anthony

Sardet	Maele Jade	<i>Tenative: ML for Process Control</i>	MechE	2022	expected
Li	Rui	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Rojrungrasathorn	Tanach	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Levi	Aviva Jesse	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Bradley	Russel	<i>Tenative: Design and Manufacture of Education Kit</i>	MechE	2022	expected
Smith	Carly Madeleine	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected
Aitmbiriq	Imane	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected
Noh	Joyce	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected
Lin	Ryan Shao-Wei	<i>Tenative: Clinical Trial Monitoring Kit Design</i>	MechE	2022	expected

Doctoral Theses, Supervisor					
Ljubicic	Dean	<i>High Speed Instrumentation for Inspection of transparent parts</i>	MechE	2013	
Gilbertson	Matthew Wright	<i>Electromechanical systems to enhance the usability and diagnostic capabilities of ultrasound imaging</i>	MechE	2014	
Sun	Shih-Yu	<i>Ultrasound probe localization by tracking skin features</i>	EECS	2014	
Zakrzewski	Aaron	<i>Arterial blood pressure estimation using ultrasound</i>	MechE	2017	
Roberts	Megan	<i>Design and fabrication of a flexible membrane ultrasound transducer</i>	MechE	2018	
Lee	John Haeseon	<i>Measuring the absolute concentration of particles in suspension using high frequency B-mode ultrasound imaging</i>	EECS	2015	
Fincke	Jonathan Randall	<i>Non-contact quantitative imaging of limbs, bone and tissue, using ultrasound tomographic techniques</i>	MechE	2018	
Ranger	Bryan	<i>Ultrasonic imaging methods for quantitative musculoskeletal tissue assessment and improved prosthetic interface design</i>	HST	2018	
Kundu	Ina Annesha Kundu	<i>Imaging skin structures for health, body mapping, and identification (under the Tucson Skin)</i>	MechE	2018	
Kim	David Donghyun Kim	<i>Design and development of desktop fiber and fabric manufacturing system for advanced materials</i>	MechE	2020	
Wang	Jenny Wang	<i>Formation Process of Acoustophoretic Patterns</i>	MechE	2022	

Theses Supervised by Brian W. Anthony

Pigula	Anne Pigula	<i>Statistical analysis of ultrasound signals for tissue characterization : the Homodyned K Distribution</i>	HST	2020	
Zhang	Xiang Zhang	<i>Non-contact ultrasound</i>	MechE	2019	
Benjamin	Alex Benjamin	<i>3D organ property mapping using freehand ultrasound scans</i>	MechE	2020	
Singh	Robin Singh	<i>Integrated bio-photonic devices : sensors, imagers, and beyond</i>	MechE	2021	
Chen	Melinda Chen	<i>Tentative: Liver Vascular Health Imaging</i>	HST	2022	expected
Chai	Lauren	<i>Tentative: Radiation Force Manufacturing</i>	MechE	2022	expected
Zubajlo	Rebecca Zubajlo	<i>Tentative: Physical Measurement of Cells</i>	MechE	2022	expected
Jaffe	Alex	<i>Tentative: Venous and Blood Pressure in the extremities</i>	EECS	2022	expected
Lange	April	<i>Tentative: Volume US - Squishy slam</i>	MechE	2023	expected
Zhang	Zhuorui	<i>Tentative: Large Aperture Wearable</i>	MechE	2024	expected
Gao	Mingye	<i>Tentative: Integrated Photonics for Biosensing</i>	EECS	2024	expected
Hahm	Katie	<i>Tentative: Ambient Gait Analysis</i>	MechE	2023	expected
Lin	QiAn	<i>Tentative: US Path Planning</i>	MechE	2024	expected
Kang	David Ha Eun	<i>Tentative: Homomorphic Encryption and ML</i>	MechE	2023	expected
Tripathy	Soumya	<i>Tentative: Integrated Photonics for US</i>	Media	2024	expected

Doctoral Theses, Reader

Shi	Chuan	<i>Efficient buffer design algorithms for production line profit maximization</i>	MechE	2011	
Petrzelka	Joe	<i>Contact region fidelity, sensitivity, and control in roll-based soft lithography</i>	MechE	2012	
Smyth	Katherine	<i>Piezoelectric micro-machined ultrasonic transducers for medical imaging</i>	EECS	2016	
Athanassiadis	Athanasios G.	<i>Optical breakdown acoustics : transduction and sensing underwater</i>	MechE	2019	

Postdoctoral Associates and Fellows Supervised by Brian W. Anthony

Current Postdocs

<i>Name</i>	<i>Dates of Appointment</i>	<i>PhD Granting Institution</i>
Shawn Zhang	2019 -	MIT
Praneeth Namburi	2020 -	MIT

Previous Postdocs

<i>Name</i>	<i>Current Title</i>	<i>Current Employer</i>
Vannah, Bill	Scientist	Mary Free Bed Rehabilitation Hospital
Victor Lempitsky	Head of AI	Samsung
Javier J. Gonzalez	May 2013 – 2015	University of Madrid
Matthew Gilbertson	Senior Electro-Optical Engineer	Lockheed Martin
Xian, Du	Professor	UMass (2018)
David Ibarra	Professor	Monterery Tec
Micha Feigin	Research Scientist	MIT
Ian Butterworth	Biomedical Research Engineer	MIT
Carlos Castro-Gonzalez		
	Co-Founder and CEO	Leuko
Berta Martí Fuster	Head of Communications	Oncoheroes Biosciences
Bonghun (Bruce) Shin	Senior Scientist	University Waterloo
Megan Roberts	Director of Product Development	Med Tech Co.
Greg Ely	Senior Algorithm Engineer	Imaging Co.
David Kim	Scientist	Sandia Labs