

Reply Declaration of Darrin Young in Support of
Petition for *Inter Partes* Review of
U.S. Patent No. 6,671,648 B2

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NINTENDO CO., LTD., and
NINTENDO OF AMERICA INC.,
Petitioners

v.

AMERICAN GNC CORPORATION,
Patent Owner.

Case IPR 2024-00668
U.S. Patent No. 6,671,648 B2

REPLY DECLARATION OF DARRIN YOUNG, PH.D.

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I, Darrin Young, declare as follows:

I. INTRODUCTION

1. My name is Darrin Young. I have prepared this declaration as an expert witness on behalf of Petitioner Nintendo Co., Ltd., and Nintendo of America Inc. In this declaration, I will provide my opinions regarding the invalidity of claims 1 and 4 (the “challenged claims”) of U.S. Patent No. 6,671,648 (the “’648 patent”; **EX1001**) in response to Dr. Lawrence Larson’s declaration (**EX2019**) and Mr. Hiram McCall’s declaration (**EX2023**). I also provide herein the technical bases for these opinions, as appropriate.

2. Along with my March 7, 2024 declaration (**EX1002**; “opening declaration”), this declaration contains statements of my opinions formed to date, and the bases and rationale for these opinions. I may offer additional opinions based on further review of materials in this case, including opinions and/or testimony of other expert witnesses.

3. For my efforts in connection with the preparation of this declaration, I have been compensated at my usual and customary rate for this type of consulting activity. My compensation is in no way contingent on the results of these or any other proceedings related to the ’648 patent.

II. BACKGROUND

4. I discussed my professional qualifications in my opening declaration and provided my resume. (EX1002, ¶¶ 4-10, Appx. A.) I provide the following additional remarks regarding my background in response to Patent Owner and its expert's arguments regarding my background.

5. I started my research work in MEMS as a graduate research student at the University of California at Berkeley between 1993 and 1994. I worked on design and simulation of a Sigma-Delta modulator architecture to interface with a capacitive MEMS accelerator. The Sigma-Delta architecture produces a one-bit digital output, which can be used to provide a digital force feedback signal to control the position of a MEMS accelerometer's proof mass at its nominal position. The one-bit digital force feedback signal further helps achieve a linear system performance. The Sigma-Delta architecture suppresses the quantization noise in the low-frequency region, where an incoming acceleration signal typically resides, thus achieving an improved signal-to-noise ratio (SNR). I also applied a digital decimation filter to the one-bit digital output to determine the incoming acceleration signal amplitude and the minimum detectable signal level. After this project, I worked on design and development of MEMS fabrication technology for fabricating surface-micromachined capacitive MEMS structures that can be used as a voltage-

controlled, tunable capacitor or a capacitive sensor to detect acceleration or vibration. I also worked on design and fabrication of an on-chip 3D coil inductor for building a MEMS-based low noise radio-frequency voltage-controlled oscillator.

6. After I received my Ph.D. degree in 1999, I joined Case Western Reserve University as an assistant professor in the Electrical Engineering Department, where I continued my MEMS research work. During my tenure there between 1999 and 2009, I designed and fabricated MEMS sensors, including accelerometers, gyroscopes, resonators, strain sensors, pressure sensors, and mixed-signal sensor interface integrated circuits. The sensor interface integrated circuits employed building blocks including low noise capacitance-to-voltage converter, capacitive pick-off circuitry, mixers, filters, reference circuits, clock generators, analog-to-digital converters, digital logic control circuits, digital encoders, etc. I also designed and implemented a fully integrated MEMS accelerometer with CMOS integrated circuits on a same chip. I worked on digital signal processing on output signals from Sigma-Delta modulator-based analog-to-digital converters using digital decimation filters to determine the analog signal amplitude at the input of the modulator. These MEMS sensors, sensor-interface circuits, and digital signal processing steps were applied to different applications including biomedical implant, motion detection, strain sensing, and personal navigation.

III. RESPONSE TO DR. LARSON

7. I have reviewed Dr. Larson's Declaration (EX2019) and provide the following opinions and analysis in response.

A. Response to Dr. Larson's Opinions re Person of Ordinary Skill in the Art and State of the Art of MEMS Inertial Sensors

8. As I discussed in my opening declaration, it is my opinion that a person of ordinary skill would have possessed a bachelor's degree in electrical engineering or similar degree, with two to three years of practical experience designing and/or implementing systems that include sensors for measuring movement, such as acceleration and rotational position. (EX1002, ¶ 14.)

9. Dr. Larson indicates that a person of ordinary skill "would have at least a Master's Degree in Electrical or Electronics Engineering, and approximately five years of relevant experience in the development of control systems for inertial navigation, MEMS semiconductor processing, and analog circuit design—with additional education substituting for experience and vice versa." (EX2019, ¶ 57.) While I proposed a different definition of a person of ordinary skill, I do not disagree with Dr. Larson's proposed definition. My opinions regarding the obviousness of the '648 patent challenged claims over the prior art, moreover, remain the same under either formulation.

10. In connection with his definition of a person of ordinary skill, Dr. Larson makes various statements with which I disagree. Dr. Larson opines that at the time of the '648 patent, “the technological development of this field – MEMS inertial sensors – was still in its early research stages.” (EX2019, ¶ 57.) Furthermore, Dr. Larson opines that “there was no established industry or large body of academic work in MEMS devices[.]” (*Id.*, ¶ 58.) I disagree with these assertions. The field of MEMS inertial sensors was at least a decade old by the time of the claimed priority date of the '648 patent and was well-established. Commercially available products containing MEMS inertial sensors were available and numerous research teams (including my own) had been working on MEMS research for years. Accordingly, in my opinion, MEMS was far more developed than its “early research stages” as Dr. Larson contends, and there was an established industry and large body of academic work in MEMS devices, including MEMS inertial sensors.

11. This is further confirmed by the prior art references cited in my opening declaration. For example, Bernstein (EX1006) issued on April 20, 1993—more than six years before the claimed 1999 priority date of the '648 patent—describes micromechanical gyroscopes for measuring angular position along a particular axis. The Background of Bernstein states that “[m]icromechanical gyroscopes which are micromachined from a single silicon substrate are now well known in the art.”

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(Bernstein, 1:11-13.) Chan (EX1005), which was filed on October 24, 1997, similarly discloses—again in the Background section—that “various microelectromechanical systems (‘MEMS’) have arisen which require the necessity to sense temperature, pressure, strain, acceleration, rotation, infrared radiation, chemical properties of liquids and gases, and other physical inputs. Accordingly, various types of microsensors have been developed which receive analog and digital electrical inputs and also sense or measure these other physical inputs, e.g., acceleration, pressure, temperature, strain.” (Chan, 1:12-20 (underlining added).) These disclosures came from the “Background” sections of Bernstein and Chan, not the later sections describing their inventions. I note that Dr. Larson does not discuss Bernstein or Chan in his declaration.

12. My own experience with MEMS inertial sensors (discussed above) indicates that the technological development of MEMS inertial sensors was more developed than Dr. Larson asserts. For example, I started working with MEMS inertial sensors as early as 1993—six years before the claimed 1999 priority date of the ’648 patent. By the time of the ’648 patent, the field had significantly advanced even from when I first started working with MEMS inertial sensors.

13. My views are supported by other evidence in the record. For instance, the inventor of the ’648 patent, Mr. Hiram McCall, indicates in his declaration

(EX2023) that Draper Labs was developing MEMS inertial sensors around the time of the '648 patent. (EX2023, ¶ 22.) Indeed, the Draper Labs was the assignee of the Bernstein patent mentioned above, whose filing date predated the priority date of the '648 patent by more than six years.

14. AGNC's own patent specification states the field of MEMS inertial sensors was far more developed than Dr. Larson's characterization—*i.e.*, that it was in its “early research stages.” (EX2019, ¶ 57.) For example, the '648 patent indicates that “proliferative MEMS angular rate sensor approaches have been developed to meet the need for inexpensive yet reliable angular rate sensors in fields ranging from automotive to consumer electronics.” (EX1001, 2:24-27 (emphasis added).) Furthermore, the '648 patent indicates that “MEMS angular rate sensors and MEMS accelerometers are available commercially and have achieved micro chip-size and low power consumption[.]” (*Id.*, 2:47-49 (emphasis added).) The '648 patent also provides the following discussion regarding MEMS sensors:

Single input axis MEMS angular rate sensors are based on either translational resonance, such as tuning forks, or structural mode resonance, such as vibrating rings. Moreover, dual input axis MEMS angular rate sensors may be based on angular resonance of a rotating rigid rotor suspended by torsional springs. Current MEMS angular rate sensors are primarily based on an electronically-driven tuning fork

method.

(*Id.*, 2:28-35.)

15. As another example, AGNC's U.S. Patent No. 6,508,122 (the "'122 patent"), which was filed on September 15, 2000 and claims priority to an application filed September 16, 1999, indicates that:

Various MEMS angular rate sensor approaches have been developed to meet the need for inexpensive yet reliable angular rate sensors in fields ranging from automotive to consumer electronics. Single input axis MEMS angular rate sensors are based on either translational resonance, such as tuning forks, or structural mode resonance, such as vibrating rings. Moreover, dual input axis MEMS angular rate sensors may be based on angular resonance of a rotating rigid rotor suspended by torsional springs. The inherent symmetry of the circular design allows angular rate measurement about two axes simultaneously.

(EX1054 ('122 patent), 1:57-67 (emphasis added).) Further, the '122 patent indicates that "[e]xample MEMS devices include inkjet-printer cartridges, **accelerometers that deploy car airbags**, and miniature robots." (*Id.*, 1:43-45 (emphasis added).)

16. Dr. Larson also asserts that "an undergraduate Engineering student would have been unlikely to have encountered opportunities to study" MEMS

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devices. (EX2019, ¶ 58.) But this assertion appears to be based on his erroneous opinion that “there was no established industry or large body of academic work in MEMS devices[,]” which is incorrect for the reasons discussed above. (*Id.*) In my opinion, given that MEMS technology was advanced at the time of the ’648 patent, including as to MEMS inertial sensors, an undergraduate would likely have been exposed to this area of technology. Moreover, it is unclear why the educational opportunities of an undergraduate student have any relevance to the obviousness inquiry. I understand from counsel that obviousness is assessed from the standpoint of a person of ordinary skill in the art, who is not a mere undergraduate engineering student. Dr. Larson’s own formulation of a skilled artisan includes not just a Master’s Degree but also “approximately five years of relevant experience in the development of control systems for inertial navigation, MEMS semiconductor processing, and analog circuit design[.]” (EX2019, ¶57.) My own formulation includes “two to three years of practical experience designing and/or implementing systems that include sensors for measuring movement, such as acceleration and rotational position.” (EX1002, ¶14.)

17. Accordingly, even if Dr. Larson were correct that an undergraduate engineering student would not likely have had an opportunity to study MEMS devices, the practical experience indicated by Dr. Larson’s formulation (and my

own) would have given a person of ordinary skill experience with MEMS devices. Indeed, as I discussed above, MEMS devices were well established in research and industry by the time of the '648 patent, including MEMS inertial sensors.

18. As noted previously, my opinions about the challenged claims of the '648 patent would not change if I were to adopt Dr. Larson's definition of a person of ordinary skill in the art. In fact, Dr. Larson's formulation appears to be higher than the one I proposed in my opening declaration. Dr. Larson's definition of a person of ordinary skill, if adopted, would only further strengthen my opinions as to the obviousness of the challenged claims over the prior art.

B. Response to Dr. Larson's Opinions re '648 Patent

19. Dr. Larson opines that incorporating MEMS sensors into an inertial measurement unit ("IMU") was a "non-trivial design and development task, with little available knowledge and literature to guide the application of MEMS technology." (EX2019, ¶ 54.) I disagree. There was ample literature regarding the application of MEMS technology and the use of MEMS sensors in an IMU, including the prior art discussed in this and my opening declaration. Accordingly, a person of ordinary skill would have had the knowledge to incorporate MEMS sensors into an IMU. At the very least, it would have been obvious to a person of ordinary skill in the art to incorporate MEMS sensors into an IMU, as I discussed

for Grounds 1 to 4 in my opening declaration. (EX1002, *e.g.*, ¶¶ 99, 104.)

C. Response to Dr. Larson re “Substitution of MEMS Sensors for Conventional”

20. Dr. Larson opines that it would not have been obvious to use MEMS sensors in the systems disclosed by the Smith, Tingleff, or Yamawaki references. (EX2019, ¶¶ 76-80.) As I discussed in my opening declaration, I disagree. (EX1002, Sections V.B., V.D., V.E.) It would have been obvious to a person of ordinary skill to use MEMS sensors in any of the Smith, Tingleff, or Yamawaki systems.

21. Dr. Larson makes various claims about the alleged difficulty of integrating MEMS sensors into an IMU—for example, opining that “integration of MEMS rate and acceleration sensors into an IMU at the time of the American GNC Patents was a difficult challenge beyond the capabilities of one of only ordinary skill[.]” (EX2019, ¶¶ 77-79.) I disagree with Dr. Larson for multiple reasons.

22. *First*, as I explained in my opening declaration, of course, some design effort would have been necessary to use MEMS sensors in the IMU designs disclosed by Smith, Tingleff, or Yamawaki. (EX1002, Sections V.B., V.D., V.E.) But these design efforts would have fallen well within the skillset of a person of ordinary skill (under Dr. Larson’s formulation or my own). I disagree with Dr.

Larson that any such design efforts would require “novel techniques,” “much experimentation,” or something beyond the capabilities of a person of ordinary skill in the art. (EX2019, ¶¶ 77-79.) Indeed, I designed and simulated mixed-signal electronics and related circuitry for interfacing with MEMS devices in the early 1990s as a graduate student at UC Berkeley, as discussed above.

23. *Second*, Dr. Larson’s opinions are based on mischaracterizations of the state of the art at the time of the ’648 patent. For example, Dr. Larson indicates that “MEMS sensors at the time required complicated electronic circuitry to reliably control, as the ’648 Patent described and taught.” (EX2019, ¶ 77.) Dr. Larson’s sole citations for this proposition consist of citations to the Abstract and to 17:19-36 of the ’648 patent specification. (*Id.*) But neither citation mentions anything about “complicated” circuitry, “reliabl[e] control,” or even what was necessarily “required” by MEMS sensors at the time. (EX1001, Abstract, 17:19-36.)

24. Furthermore, Dr. Larson opines that the field of applying MEMS sensors in practice was “nascent.” (EX2019, ¶ 78.) I disagree. As I discuss throughout my opening declaration and above, MEMS technology, including MEMS inertial sensors, had existed for many years at the time of the ’648 patent. There were many commercial devices, including MEMS inertial sensors, available at the time of the ’648 patent. Furthermore, a substantial body of research on MEMS

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technology existed at the time of the '648 patent.

25. Dr. Larson also opines that my testimony related to a project I worked on after the alleged priority date of the '648 patent supports his opinion that using MEMS sensors was not routine. (EX2019, ¶ 80.) I disagree.

26. In my deposition, I testified about a research project I worked on starting in 2007, which involved incorporating a MEMS sensor into the shoe of a soldier to allow for position tracking in environments that lacked GPS signals. I worked on this project while I was a professor at Case Western Reserve University. I designed a flexible tactile sensor-based ground reaction sensor array and incorporated the sensor array as a part of shoe's insole. A commercial MEMS IMU was also installed to the shoe as a part of an overall personal navigation system. I understand that Patent Owner focuses on the fact that this project extended over a number of years. But as I testified in my deposition, the duration of this project resulted from the fact that it was a training opportunity for graduate students, and because there were changes in funding throughout the course of the project. Furthermore, this was a very specific application of MEMS sensors in a demanding application context (*i.e.*, a wearable shoe).

27. In my deposition, I also testified about a research project I worked on starting in 2003. In that project I designed a MEMS accelerometer and attached the

accelerometer on the ossicular chain in the middle ear. The accelerometer detects the vibration of the ossicular chain when an acoustic stimulation is applied to the ear drum. The accelerometer, therefore, can serve as an implantable microphone for fully implantable cochlear prosthetic applications. As I testified in my deposition, the duration of this project resulted from the fact that it was a training opportunity for graduate students, for instance. Furthermore, this was a very specific application of MEMS sensors in a demanding application context (*i.e.*, implanted in the human ear).

D. Response to Dr. Larson’s Opinions re “Digital Signal Processing with MEMS Gyroscopes”

28. I understand that the section of Dr. Larson’s declaration related to “Use of Digital Signal Processing with MEMS Gyroscopes” relates to the ’122 patent in the parallel IPR2024-00667 proceeding—not the ’648 patent. However, to the extent there is any argument that certain of Dr. Larson’s opinions in this section pertain to the challenged claims of the ’648 patent, I have provided my responsive opinions below.

29. Dr. Larson opines that a person of ordinary skill would not have had sufficient experience with digital signal processing. (EX2019, ¶¶ 81, 84.) I disagree. In my opinion, a person of ordinary skill in the art would have had sufficient

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experience with and knowledge about digital signal processing to use such processing in a MEMS IMU, as I discuss in my opening declaration regarding Grounds 1 to 4. In my opinion, a person of ordinary skill would have had experience and familiarity with digital signal processing based on their education and work experience. As I discussed in my opening declaration, it is my opinion that a person of ordinary skill would have had a Bachelor's degree in electrical engineering or similar degree, with two to three years of practical experience designing and/or implementing systems that include sensors for measuring movement, such as acceleration and rotational position. (EX1002, ¶ 14.) In my opinion, a person of ordinary skill would have gained experience and familiarity with digital signal processing during their undergraduate education and through their practical experience. For example, by the time of the '648 patent, I had experience with mixed-signal processing both based on my undergraduate educational experience and my practical experience working on mixed-signal design and simulation for MEMS accelerometers.

30. Furthermore, as I discuss below in response to Mr. McCall's declaration, whether a person of ordinary skill in the art had Mr. McCall's allegedly advanced experience with digital signal processing techniques has no bearing on the challenged claims, because the challenged claims do not require any particularly

sophisticated forms of digital signal processing. (*See infra* Section IV.)

31. Dr. Larson opines that a person of ordinary skill would not have known how to apply “sophisticated signal processing techniques,” “complicated” digital signal processing, or undefined “algorithms” to a MEMS inertial sensor. (EX2019, ¶¶ 82-84.) Again, it is not clear if these arguments are directed to his opinions about the ’648 patent, but to the extent they are, I disagree.

32. Nothing in the challenged claims of the ’648 patent requires the complicated or sophisticated digital signal processing techniques—nor would a person of ordinary skill have viewed such techniques to be complicated or sophisticated. Rather, the only recitation of digital signal processing in the challenged claims is the requirement in claim 1 of conversion of angular rate electrical signals and acceleration electrical signals into “digital angular increments and digital velocity increments respectively.” Nothing in this language requires a complicated or sophisticated use of digital signal processing as Dr. Larson suggests. (EX2019, ¶¶ 82, 84.) Furthermore, a person of ordinary skill would not have understood the language of claim 1 to require a “complicated application of digital signal processing[.]” (*Id.*, ¶ 84) Rather, claim 1 merely requires converting angular rate electrical signals and acceleration electrical signals into “digital angular increments and digital velocity increments respectively.” A person of ordinary skill

would have understood that this conversion step could be achieved via routine digital signal processing. A person of ordinary skill would not have understood that any particular complicated or sophisticated digital signal processing would have been necessary to meet the requirements of claim 1.

33. Dr. Larson also opines that MEMS technology was in its “infancy” or an “immature state” at the time of the ’648 patent. (EX2019, ¶¶ 82, 83.) I disagree. As I discuss throughout this and my opening declaration, MEMS technology, including MEMS inertial sensors, had existed for many years at the time of the ’648 patent. There were many commercial devices, including MEMS inertial sensors, available at the time of the ’648 patent. Some examples of MEMS inertial sensors commercially available prior to the ’648 patent include the Analog Devices ADXL05, the Analog Devices ADXL50, the Crossbow DMU-6X, the Crossbow DMU-VGX, and the MSI ACH-04-08-05. (EX1063 (MSI ACH-04-08-05 data sheet); EX1064 (Analog Devices ADXL05 data sheet); EX1065 (Analog Devices ADXL50 data sheet); EX1053 (Crossbow DMU-6X and DMU-VGX data sheet).) Furthermore, a substantial body of research on MEMS technology existed at the time of the ’648 patent.

34. Dr. Larson opines that a person of ordinary skill “would only find digitization ... to be obvious *in hindsight*[.]” (EX2019, ¶ 83 (*italics in original*).) I

disagree.

35. My own experience in the early 1990s as a graduate student at UC Berkeley contradicts Dr. Larson’s opinion. I worked on digital signal processing in MEMS sensor control loops years before the ’648 patent.

36. Furthermore, in my opinion, various prior art references contradict Dr. Larson’s opinion. For example, I discuss the Hulsing and Minor references below, which discuss the use of digital signal processing with MEMS sensors. (EX1047 (Hulsing, “MEMS Inertial Rate and Acceleration Sensor” (1998); EX1038 (Minor, “Utilization of GPS/MEMS-IMU for Measurement of Dynamics for Range Testing of Missiles and Rockets” (1996)).)

IV. RESPONSE TO MR. MCCALL

37. I have reviewed Hiram McCall’s Declaration (EX2023) and provide the following opinions and analysis in response.

38. Mr. McCall indicates that AGNC has had commercial success due to the alleged inventions of the ’648 patent. (EX2023, ¶¶ 3, 20.) However, Mr. McCall provides no evidence of any commercial success by AGNC. Furthermore, Mr. McCall provides no analysis to indicate that any commercial success by AGNC was attributable to the alleged inventions of the ’648 patent.

39. Mr. McCall opines that his level of experience in digital signal

processing was out of the ordinary for engineers working in MEMS sensors at the time. (EX2023, ¶ 6.) In my opinion, to the extent Mr. McCall had a higher level of experience in digital signal processing than a person of ordinary skill, it has no bearing on the challenged claims. As I discuss above, the challenged claims merely require conversion of angular rate electrical signals and acceleration electrical signals into “digital angular increments and digital velocity increments respectively.” In my opinion, a person of ordinary skill in the art did not have needed to possess sophisticated experience with digital signal processing (or Mr. McCall’s alleged level of experience) for it to have found the challenged claims obvious, or to have implemented the claimed “digital angular increments and digital velocity increments” with MEMS inertial sensors.

40. Mr. McCall opines that building a “commercially and technically viable gyroscope from silicon MEMS technology” was seen as a “significant technical challenge” before the ’648 patent. (EX2023, ¶ 7.) I disagree. In my opinion, there were many examples of commercially and technically viable gyroscopes from silicon MEMS technology in products and research prior to the ’648 patent. (*See, e.g.*, EX1057 (WO 97/45699 to William A. Clark), 1:5-7, 29:13-24, 41:20-42:10, 43:17-19, Figs. 9 & 18; EX1037 (Juneau, “Micromachined Dual Input Axis Rate Gyroscope” (1998)), pp. 4-5, 66-79, Fig. 4-1; EX1053 (“Crossbow DMU-6X and

DMU-VGX Silicon IMU and Vertical Gyro” (1998)).)

41. Furthermore, in my opinion, whether a commercially and technically viable gyroscope from silicon MEMS technology was seen as a significant technical challenge prior to the '648 patent has no bearing on the challenged claims. Even if this statement were accurate (which it is not as described above), nothing in the challenged claims requires a commercially and technically viable gyroscope from silicon MEMS technology.

42. Mr. McCall makes various claims about the use of MEMS sensors in vehicular navigation including aircraft. (EX2023, ¶¶ 8, 10, 12.) For example, Mr. McCall opines that “MEMS gyroscope designs did not have sufficient stability and performance to meet what would have been the requirements of an IMU for an aircraft or missile system.” (*Id.*, ¶ 12.) I disagree with Mr. McCall as to any suggestion that MEMS sensors would not have been considered adequate for use in vehicular navigation including aircraft. As I discussed in my opening declaration, there were ample disclosures in the prior art to the '648 patent regarding use of MEMS sensors in vehicular navigation including aircraft. (EX1002, ¶¶ 48, 54-59, 67, 76-78.) Furthermore, as I discussed in my opening declaration, it would have been obvious to a person of ordinary skill to use MEMS sensors in aircraft navigation. (EX1002, ¶¶ 99, 156.) For example, it would have been obvious to a

person of ordinary skill to use MEMS sensors as a backup navigational sensing system in an aircraft. (EX1002, ¶¶ 99, 156.)

43. Mr. McCall also opines that it would not have been obvious to “replace the accelerometer and gyroscope elements in a conventional system, such as one using a ring laser gyroscope, with MEMS acceleration and rate sensors.” (EX2023, ¶¶ 24-25.) I disagree with Mr. McCall. As I discussed in my opening declaration, some design efforts would be necessary by a person of ordinary skill in the art to use MEMS sensors in the IMU designs disclosed by Smith, Tingleff, or Yamawaki. However, in my view, any such design efforts would have been within the skillset of a person of ordinary skill, and these would not have changed the fact that a person of ordinary skill would have found the combinations for Grounds 1 to 4 obvious. I disagree with Mr. McCall’s assertions that any such efforts would “require[] substantial expertise, design, and experimentation[.]” (EX2023, ¶ 25.)

44. Furthermore, Mr. McCall’s opinions appear to be based on the efforts that were required to “produce the American GNC coremicro IMU product.” (EX2023, ¶ 25.) However, neither Mr. McCall, Dr. Larson, nor AGNC have provided any evidence or analysis to indicate that any product—including the coremicro IMU product—embodies or in any way relates to the ’648 patent. Accordingly, Mr. McCall’s opinions regarding any efforts related to an AGNC

product have no bearing on the challenged claims in my opinion.

V. FURTHER RESPONSIVE OPINIONS

A. Response to Dr. Larson and Mr. McCall's Claims About the Alleged Difficulty of Using MEMS Sensors in an IMU Prior to the '648 Patent

45. Both Dr. Larson and Mr. McCall make claims about the alleged difficulty of using MEMS sensors in an IMU prior to the '648 patent. For example, Dr. Larson opines that “integration of MEMS rate and acceleration sensors into an IMU at the time of the American GNC Patents was a difficult challenge beyond the capabilities of one of only ordinary skill, in what was a rapidly developing art.” (EX2019, ¶ 78.) Furthermore, Mr. McCall states that, prior to the '648 patent, “an Inertial Measurement Unit (IMU) that would incorporate and utilize such MEMS gyroscope technology ... was seen as a significant technical challenge at the time, in large part due to the difficulties presented by the existing micromechanical sensor designs.” (EX2023, ¶ 7.) However, these claims are undermined by the fact that MEMS IMUs existed and were disclosed in the prior art to the '648 patent. For example:

a. The article “MEMS Inertial Rate and Acceleration Sensor,” by Rand Hulsing (“Hulsing”), is prior art to the '648 patent, including because it was published in November 1998 prior to the alleged priority date of the '648 patent.

(EX1047.) Hulsing discloses a “MEMS Inertial Measurement Unit (IMU)”:

Development of the μ SCIRASTM (pronounced micro-Cyrus) multisensor for a period of over six years has produced a practical MEMS Inertial Measurement Unit (IMU). Using only three silicon sensors, a full-up IMU suitable for tactical grade navigation and guidance applications has been achieved. Iterative improvements in silicon sensor design and bulk micromachining processes have matured to the point where an IMU with an attractive price/performance ratio is now producible. This paper summarizes the design features and test results for an IMU with < 100 deg/hr performance.

(EX1047 at 17.) Furthermore, Hulsing discloses the use of digital signal processing with its MEMS IMU, as shown in the following figure:

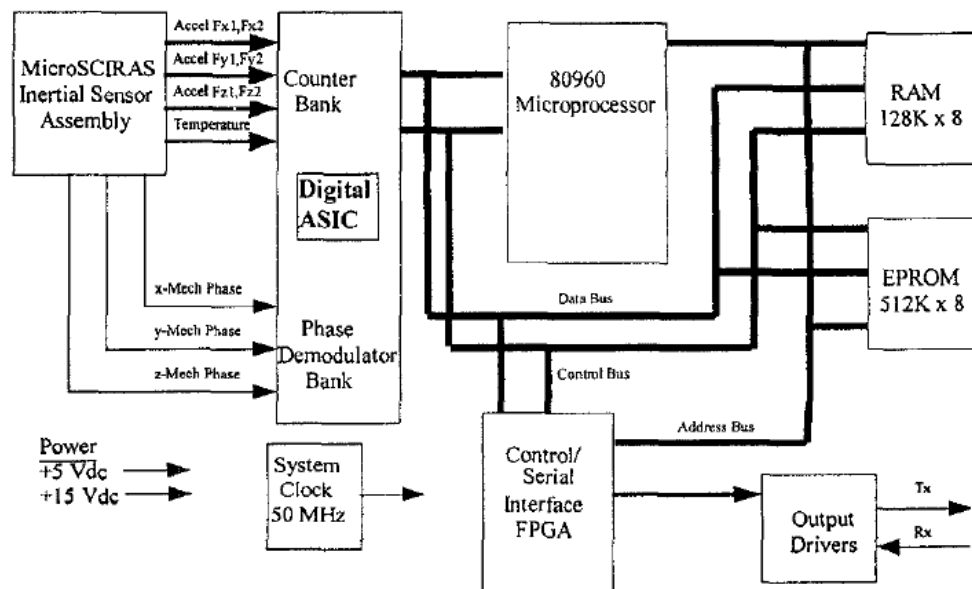


Fig. 5. Microprocessor

(*Id.*, Fig. 5.) Dr. Larson testified that he had never seen the Hulsing article before.

(EX1046, 34:14-35:3 (“I have not seen this article before.”).)

b. The article “Utilization of GPS/MEMS-IMU for Measurement of Dynamics for Range Testing of Missiles and Rockets,” by Roy R. Minor *et al.* (“Minor” (EX1038)), is prior art to the ’648 patent, including because it was published in 1996 before the alleged priority date of the ’648 patent. Minor discloses “a small, low cost, integrated GPS receiver and MEMS-IMU embedded in the missile/rocket to provide (via telemeter link) accurate position, velocity, attitude, and time information of the missile/rocket during test flights.” (EX1038 at 602.) Minor includes the following diagram showing a MEMS IMU:

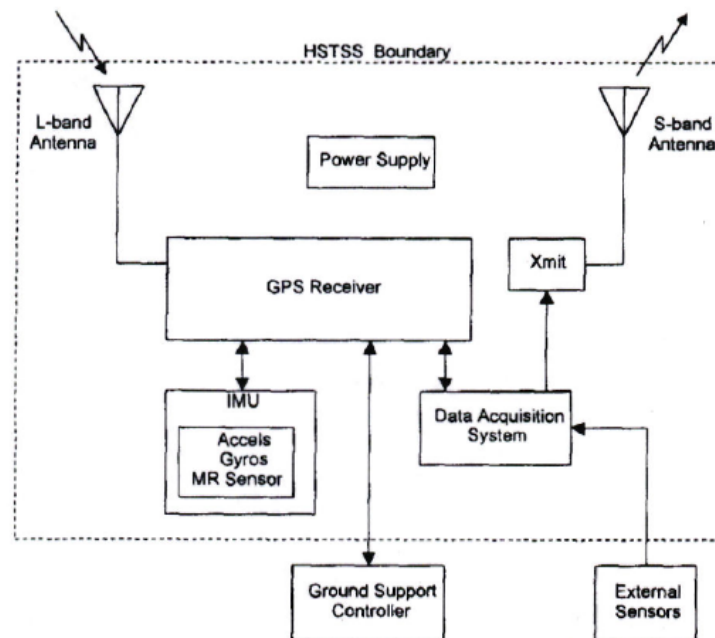


Figure 1 HSTSS Architectural Diagram.

(EX1038, Fig. 1.) In addition to showing that MEMS IMUs were available in the

prior art contrary to Dr. Larson and Mr. McCall's representations, Minor contradicts Dr. Larson and Mr. McCall's representations about the alleged inapplicability of MEMS sensors to aviation, since Minor discloses the use of MEMS IMUs for missile navigation. (EX1038 at 602.) Mr. McCall testified that he had never seen the Minor article before. (EX1048, 23:5-16.)

**B. Claim construction of “angular rate electrical signals” and
“angular rate voltage signals”**

46. I understand that Patent Owner is asserting that the term “angular rate electrical signals” must directly measure and reflect angular rate. (POR at 24-26.) I disagree. In my opinion, while a person of ordinary skill would have understood that “angular rate electrical signals” have to relate to the angular rate, there is nothing in the claim that suggests a further requirement that the claimed angular rate electrical signals must also directly measure and reflect angular rate.

47. In my opinion, a person of ordinary skill would have understood “angular rate electrical signals” or “angular rate voltage signals” as referring to electrical signals or voltage signals, respectively, that can be used to determine an angular rate. The term, properly understood, does not require any particular relationship between the signals and the underlying angular rate, such as directly measuring and reflecting the angular rate. For example, “angular rate electrical

signals” or “angular rate voltage signals” can relate to an angular rate (1) based on the amplitude of a signal (*e.g.*, large angular rate encoded as a large electrical quantity) or (2) based on the frequency of an alternating current signal (*e.g.*, large angular rate encoded as a high frequency of the signal).

48. My opinions are also supported by dependent claim 4 of the ’648 patent, which depends from claim 1 and requires that “angular rate electrical signals” are “directly proportional to angular rates.” This would have suggested to a person of ordinary skill that “angular rate electrical signals” and “angular rate voltage signals” can have any relationship to angular rate.

49. Also, Patent Owner’s proposal that “angular rate electrical signals” or “angular rate voltage signals” directly measure and reflect angular rate has no support—and even contradicts the evidence in the specification. For example, the ’648 patent specification discloses that an example of an angular rate producer is a sensor with vibrating tines. (EX1001, 16:46-17:18.) When the system undergoes an angular rate, the vibrating tines experience Coriolis force, which can be measured to output an angular rate electrical signal. (*Id.*) For example, the specification discloses angular rate producers that measure *other* forces (*i.e.*, torsional Coriolis forces on vibrating tines) that can be used to calculate angular rate. (*Id.*) However, in my view, this undermines Patent Owner’s “directly measure” proposal, because

such angular rate producers as the specification discloses are measuring a different quantity from which an angular rate can be determined.

50. Even if Patent Owner's construction were correct and "angular rate electrical signals" were required to directly measure and reflect angular rate, it would not change my view that the challenged claims of the '648 patent are obvious in light of the prior art. Patent Owner argues that ring laser gyroscopes like those disclosed by Smith do not output "angular rate electrical signals" per claim 1 of the '648 patent because the output of a ring laser gyroscope is an alternating current signal with a frequency that changes with the measured angular rate. (POR at 43-44.) However, in my view, a person of ordinary skill would have understood that an alternating current signal with a frequency that relates to angular rate is a signal that directly reflects angular rate.

51. Patent Owner argues that Smith's system does not satisfy the "angular rate electrical signals" limitation because "the 'pulse repetition rate,' *not the signal itself*, is proportional to angular rate)." (POR at 26 (*italics in original*)). However, this argument shows a mistaken understanding of Smith's system. For Smith's system, the pulse repetition rate output by gyros **42**, **44**, and **46** *is* the signal. (Smith (EX1003), 8:3-6 ("Each ring laser gyro **42**, **44**, and **46** produces an output digital signal having a pulse repetition rate proportional to the rate of angular displacement

of each gyro **42**, **44**, and **46** about its coordinate axis.”); EX1002, ¶¶ 107-108.) In other words, information is encoded as the pulse repetition rate over time. Accordingly, there is no basis to Patent Owner’s attempted distinction between the pulse repetition rate and the “signal” in Smith’s system. And even if the claims required a signal’s *amplitude* to encode angular rate information rather than a signal’s *frequency*, it would have been straightforward to a person of ordinary skill to convert between one type of signal or the other. Nothing about either of these types of signals—or conversion between them—was inventive prior to the ’648 patent.

52. Additionally, as I discussed in my opening declaration, the “angular rate electrical signals” limitation would have been obvious in light of Smith and Bernstein. Bernstein, for instance, discloses electrical signals that are directly proportional to the angular rate. (EX1006, 2:57-59, 3:3-5 (“The voltage required to rebalance the gyroscope about the X axis is the measured output of the gyroscope, and is proportional to the input rate.”) (underlining added)).)

53. Furthermore, even if Patent Owner’s construction were correct, “angular rate electrical signals” were required to directly measure and reflect angular rate, and there is any question that such signals are disclosed by Smith, Tingleff, or Yamawaki, it is my opinion that these signals would have been obvious in light of

the prior art. In my opening declaration, I provided my opinion that claim 4—including the requirement of “analog angular rate voltage signals directly proportional to angular rates of a carrier”—would have been obvious over Smith in light of Irwin and Merhav. (EX1002, ¶¶139-150.) Furthermore, I provided my opinion that claim 4 would have been obvious over each of (1) Tingleff and (2) Yamawaki. (EX1002, ¶¶173-180, 209-216.) It is my opinion that the same obviousness analysis I provided in my opening report would apply to claim 1 if “angular rate electrical signals” were required to directly measure and reflect angular rate. Accordingly, in my view, claim 1 would have at least been obvious in light of grounds 1 to 4 if Patent Owner’s construction of “angular rate electrical signals” were found to be correct.

54. Furthermore, even if Patent Owner’s construction were correct, “angular rate electrical signals” were required to directly measure and reflect angular rate, and there is any question that such signals are disclosed by Smith, Tingleff, or Yamawaki, it is my opinion that these signals would have been obvious in light of the prior art. As I discussed in my opening declaration, it would have been obvious and basic knowledge of a skilled artisan that a rotation sensor would have produced a signal proportional to the rotation it is measuring. (EX1002, ¶¶139-150.) Accordingly, it would have been obvious that the electrical signals produced by the

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angular producer would have directly measured and reflected the angular rate of the carrier.

VI. CONCLUSION

55. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in this proceeding. If required, I will appear for cross-examination at the appropriate time. I reserve the right to offer opinions relevant to the invalidity of the challenged claims at issue and/or offer testimony in support of this Declaration.

56. I hereby declare that all statements made herein of my own knowledge are true and that all statements are made on information and belief are believed to be true, and further 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 18 U.S.C. § 1001.

Dated: 4-15-2025

Respectfully submitted,


Darrin Young