

Case No. IPR2023-00229
Patent No. 11,019,509

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS, INC.,
Petitioner,

v.

CONSTELLATION DESIGNS, LLC,
Patent Owner.

Case No. IPR2023-00229
U.S. Patent No. 11,019,509

**DECLARATION OF GERHARD BAUCH REGARDING PATENT
OWNER'S PRELIMINARY RESPONSE FOR *INTER PARTES REVIEW* OF
U.S. PATENT NO. 11,019,509**

TABLE OF CONTENTS

I.	Introduction	3
II.	Qualifications	3
III.	Materials Considered	6
IV.	<i>Bauch</i>	7
A.	<i>Bauch's</i> Constellation	8
B.	<i>Bauch's</i> System Was Designed For Broadcast Communications	10
C.	<i>Bauch</i> Uses Convolutional Codes with Iterative Detection – Not Turbo Codes – to Resolve Ambiguous Bits.....	11
D.	I Considered and Rejected Using LDPC Codes Because The Utilized Convolutional Codes Were Precisely Matched to The Constellation.....	14
V.	<i>Bauch's</i> Constellation Should Not be Used With LDPC Codes	15
VI.	The Approach Described in <i>Bauch</i> Creates a Hierarchical System But Was Not Designed for Performance, Improved Bandwidth Efficiency, or Reduced Detection Complexity When Compared to A Traditional Equally Spaced Constellation.....	17
A.	Iterative Detection Increases Complexity When Compared to An Equivalent System that Does Not Perform Iterative Detection	17
B.	<i>Bauch's</i> Constellation Does Not Provide Improved Performance When Compared to A Traditional Equally Spaced Constellation.....	17
C.	<i>Bauch's</i> Constellation Does Not Provide Improvements in Bandwidth-Efficient Transmission When Compared to A Traditional Equally Spaced Constellation	18
D.	<i>Bauch's</i> Constellation Does Not Provide Reduced Detection Complexity When Compared to A System That Does Not Perform Iterative Detection.....	19

I, Dr. Gerhard Bauch, hereby declare as follows:

I. Introduction

1. My name is Gerhard Bauch. I have been retained in the above-referenced *inter partes* review proceeding by Constellation Designs, LLC, to evaluate United States Patent No. 11,019,509 (the “509 patent”) against certain references that are presented by the Petitioner. As detailed in this report, it is my opinion that the Petition does not establish that all of the challenged claims are anticipated or rendered obvious by the references presented by the Petitioner. If requested by the Patent Trial and Appeal Board, I am prepared to testify at trial about my opinions expressed herein.

II. Qualifications

2. I have over twenty two years of experience in the field of digital communications, coding, information theory, and telecommunications. As of 2023, I was named the Dean of the School of Electrical Engineering, Computer Science and Mathematics of Hamburg University of Technology (TUHH) in Hamburg, Germany. For ten years prior to 2023, I was the Head of the Institute of Communications of Hamburg University of Technology.

3. Prior to my appointment as the Head of the Institute of Communications of Hamburg University, I was a Full Professor for Information Processing at the Universität der Bundeswehr in Munich, Germany, in particular, from 2009 to 2012. I also spent five years as an adjunct professor at the Technische Universität

München. I also held various positions as a visiting researcher with AT&T Labs Research, a research associate with the Institute for Communications with Technische Universität München, and a Scientific Staff Member with the Institute of Telecommunications of the German Aerospace Center (DLR).

4. I am also a member of various committees. In particular, I currently serve as an Executive Vice Present of IEEE Vehicular Technology Society (VTS), a Member of the Board of Directors of the Information Technology Society (ITG) of the Association for Electrical, Electronic & Information Technologies (VDE), an Elected member of the review board of the German Research Foundation (DFG), a Chair of the German Chapter of the IEEE Communications Society, and as a Member of the Selection Committee and Liaison Lecturer of the Studienstiftung des Deutschen Volkes (German Academic Scholarship Foundation). I have also served as the Vice Chair and the Chair of the German Chapter of the IEEE Information Theory Society and the Vice President Mobile Radio of the IEEE Vehicular Technology Society (VTS).

5. I am also privileged to have received various honors: Fellow of the Asia-Pacific Artificial Intelligence Association (AAIA), Certificate of Honor of the Information Technology Society (ITG) of the Association for Electrical, Electronic & Information Technologies (VDE), Fellow of the Institute of Electrical and Electronics Engineers (IEEE), Distinguished Lecturer of the IEEE Vehicular

Technology Society, Best Paper Award of the IEEE Globecom Conference multiple times, Best Paper Award of the IEEE International Conference on Communications (ICC), DOCOMO Euro-Labs Company Awards, Dissertation Award of the Information Technology Society (ITG) in VDE, Texas Instruments Dissertation Award of Technische Universität München (TUM), and Best Paper Award of the European Personal Mobile Communications Conference (EPMCC).

6. I received my Ph.D. in 2001 from Technische Universität München, my Masters in Electrical Engineering and Information Technology from Technische Universität München in 1995, and my Masters in Economics from FernUniversität Hagen.

7. I have authored or co-authored around 300 publications in the areas of computer networks and telecommunications. My publication and patents are listed on my curriculum vitae, which is attached hereto as Exhibit 2013.

8. One of my publications was cited and relied upon by the Petitioner. Specifically, I am co-inventor and co-author of the *Bauch* reference cited by the Petitioner as EX1004, which is a Patent Cooperation Treat application publication WO2006/089569 entitled “Method and Apparatus For Transmitting and Receiving Bit Interleaved Coded Modulation Signal”.

9. I am author of another such publication, titled “Turbo modulation and coding: Design and evaluation of iterative bit-interleaved coded modulation methods for wireless systems beyond 3G” relied upon the Patent Owner and cited as EX2017.

10. Further, as a result of my background in information and communication theory, I have extensive knowledge regarding the state of the technical art in this area at the time of filing of the ‘509 patent.

III. Materials Considered

11. In preparing this declaration, I have reviewed the specification and claims of U.S. Patent No. 11,019,509 (“‘509 Patent” (EX1001)) and the file history of the ‘509 patent (EX1002). I understand the ‘509 patent was issued on May 25, 2021 from U.S. Patent Application No. 16/728,384, which forms part of a chain of continuations including application Ser. No. 12/156,989 filed Jun. 5, 2008 and issued on Jul. 12, 2011 as U.S. Pat. No. 7,978,777, which claimed priority to U.S. Provisional Application 60/933,319 filed Jun. 5, 2007. (EX1001).

12. I have also reviewed the Petition, declaration of Dr. Bertrand Hochwald (EX1003) and all publications and exhibits cited in the Petition including:

- WO 2006/089569 to Bauch et al. (“Bauch” EX1004).
- U.S. Patent Publication No. 2004/0054960 to Eroz et al. (“Eroz” EX1005).

IV. Bauch

13. As noted above, I am lead author and inventor of *Bauch*. (EX1004). Alongside my coauthor, I personally developed the constellations and communication techniques described in the *Bauch*.

14. Rather than trying to improve system performance, in *Bauch* we described an approach that created a hierarchical system in which some bits are more reliable and some bits are less reliable. (EX1004 at 13:17-34; 14:19-25; 14:32-38; 15:5-7; 15:14-36). In order to achieve a hierarchical system, our constellation we describe in *Bauch*:

(1) assigns constellation points multiple labels (referred to as non-unique mappings);

(2) assigns, for non-unique mappings, labels to have some bits in common and some bits that differ from other labels of the non-uniquely mapped constellation point; and

(3) couples this constellation with a weak code called a convolutional code – not a turbo code – and which has been *precisely* matched to the constellation.

15. With this constellation, the common bits are easier to resolve because there is a greater distance between point locations. However, the bits that differ are ambiguous. Our approach as described in *Bauch* therefore relies on the error

correcting capabilities of the convolutional code to resolve the ambiguous bits via iterative detection (*i.e.*, further iterations between the decoder and the demapper).

16. Because in *Bauch* we went to great care to precisely match the convolutional code to the proposed constellation, the system can resolve the common bits with a single pass of the decoder, and then rely on the error correcting capabilities of the convolutional code during *iterative detection* to resolve the ambiguous bits. (EX1004 at 1:25-34; 11:6-10). This approach creates (1) high priority data bits (the common bits) with robust error protection that can be resolved in a single pass of the decoder with a low complexity receiver and (2) lower priority data bits (the ambiguous bits) with less robust error protection that can only be resolved with a higher-complexity higher-cost receiver capable of performing iterative detection (*i.e.*, iterations between the decoder and the demapper). (EX1004 at 1:25-34, 14:19-25, and 20:28-32 to 21:1-8). But in *Bauch* we explained that if the error correction code is not carefully chosen, error free communication may not be possible. (EX1004 at 10:31-35).

A. *Bauch's* Constellation

17. In order to achieve a hierarchical system, *Bauch's* constellation includes at least one constellation point having multiple labels, and the assigned labels have some bits in common and some bits that differ from one another. Figure 6b (reproduced below) illustrates an example constellation having non-unique

mappings. The illustrated example is an 8-PSK, that is, a constellation with 8 points. There are, however, only 8 unique locations such that each unique location has 2 associated labels. Each of the 8 unique locations are shown with the two labels associated with the point that resides at that location.

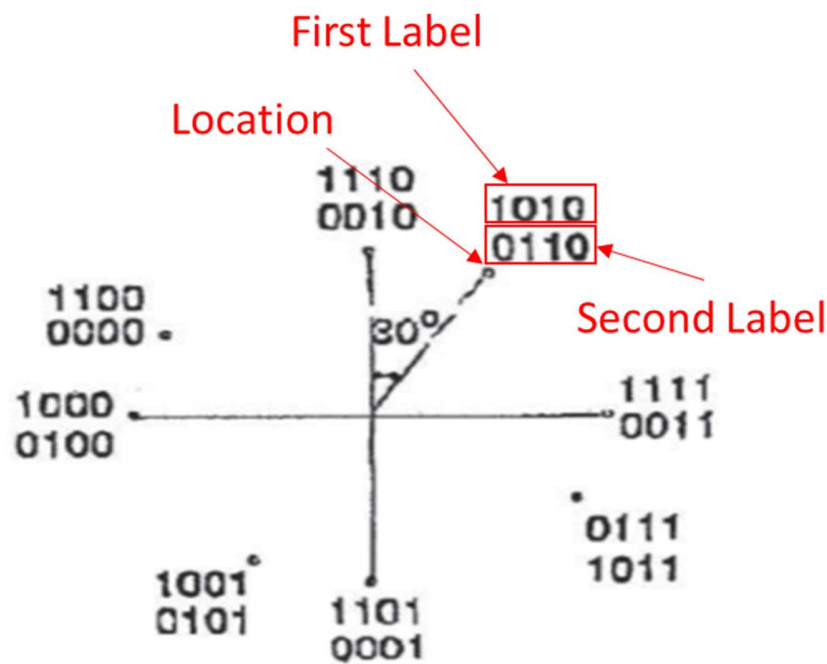


FIG. 6b

18. For each unique location, the labels include a first set of two bits that are different (ambiguous) and a second set of bits that are common. (EX1004 at 14:32-38, 20:28-34).

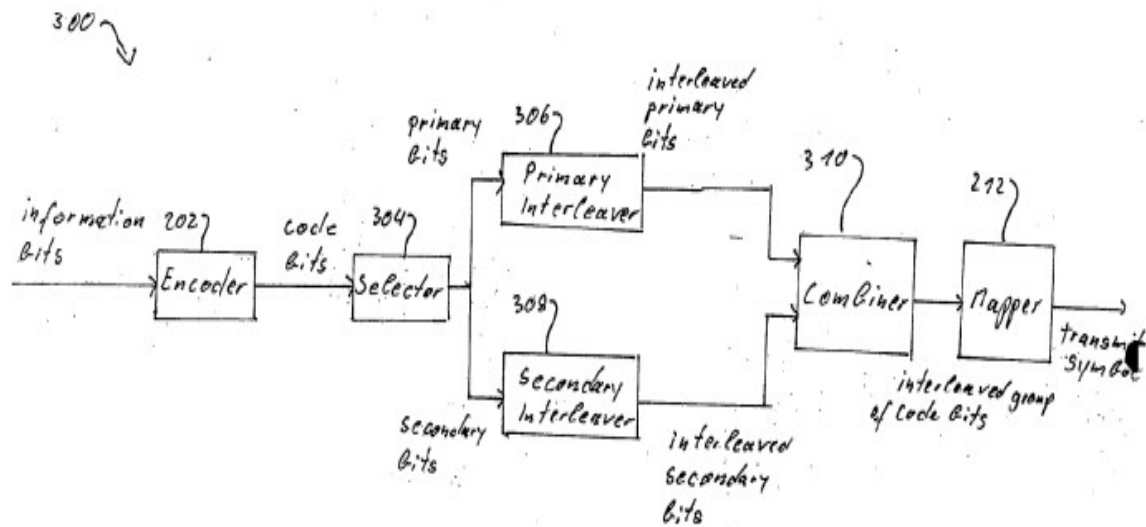


FIG. 3a

21. As shown in in Figure 3a above, the transmitter includes a selector configured to receive code bits and separate these bits into (1) primary bits that are mapped onto common (non-ambiguous) positions and (2) secondary bits are mapped onto different (ambiguous) positions. (EX1004 at 14:34 to 15:3; 15:14-36). The transmitter of *Bauch* also includes a primary interleaver that operates to interleave a sequence of primary bits and a secondary interleaver that operates to interleave a sequence of secondary bits. (EX1004 at 20:34-38 to 21:1).

C. *Bauch* Uses Convolutional Codes with Iterative Detection – Not Turbo Codes – to Resolve Ambiguous Bits

22. With non-uniquely mapped constellation points some bits are ambiguous. *Bauch* teaches using an error correcting code with iterative detection (*i.e.*, further iterations between the decoder and the demapper) to resolve the

ambiguous bits. (EX1004 at 1:25-34; 11:6-10). And not just any error correcting code, but a code that has been *precisely* matched to the constellation in order to resolve the ambiguous bits. (EX1004 at 1:25-28, 10:31-35, 11:6-10). *Bauch's* precisely chosen code is a convolutional code – not a turbo code. (EX1004 at 1:25-28; 4:27-32; 15:7-11; 24:1-3; 26:33-36).

23. Any assertion that *Bauch* uses a Turbo code is not true.

24. We clearly described that the code utilized is a convolutional code, for example, *Bauch* states:

- “A particularly interesting scheme is the concatenation of an error correction code, e.g., **a convolutional code**.” (EX1004 at 1:25-28).
- “The block diagram is depicted in Figure 14. The data is encoded by the encoder 1402 of a ...forward error control (FEC) code, e.g. by a binary **convolutional code**.” (EX1004 at 1:25-28).
- “According to this embodiment, a rate-compatible punctured **convolutional (RCPC) code** [is used] as defined in ‘J. Hagenauer. Rate-compatible punctured **convolutional codes** (RCPC codes) and their applications.’” (EX1004 at 15:8-12).
- “It is proposed to use a rate-compatible punctured code for FEC coding, e.g. a rate-compatible punctured **convolutional (RCPC) code**.” (EX1004 at 24:1-3).

- “Fig. 7 shows simulation results for the BER performance of the partially unique mappings in Figs. 6a-6d. For channel coding a rate 1/3 **convolutional code was used.**” (EX1004 at 26:33-36).

25. Moreover, any use of the word “turbo” in *Bauch* is with respect to iterative detection (*i.e.*, further iterations between the decoder and the demapper). In *Bauch* we refer to iterative detection, which is the iterative process of feeding information from the decoder back to the demapper, as “turbo detection” or “turbo iterations”, which should not be confused with “turbo codes”. To resolve any doubt, in *Bauch*, we, for example, stated “Bit interleaved coded modulation with iterative (“turbo”) detection is considered.” (EX1004 at 4:27-32).

26. My co-authors and I did not develop and did not describe using turbo codes with the constellations described in the *Bauch* publication. In that publication, we refer only to turbo iterations or turbo detections, which are synonymous with iterative decoding and demapping, and refers to the feeding back of information from the decoder to the demapper. Instead, our disclosed approach required the use of a weak code such as a convolutional code. And that is what we disclosed. Indeed, a stronger code such as a turbo code or LDPC code would not have reasonably worked with the disclosed constellations.

D. I Considered and Rejected Using LDPC Codes Because The Utilized Convolutional Codes Were Precisely Matched to The Constellation

27. Not only did we disclose that convolutional codes were necessary but we precisely matched the strength of the convolutional codes to the constellation. For example, *Bauch* teaches that “Extrinsic information transfer (EXIT) charts.... are a powerful tool for evaluation of the convergence properties of turbo detectors.” (EX1004 at 9:5-10). And “error free detection... is possible, if the trajectory can proceed through a tunnel between the two curves, i.e. the demapper and decoder curves do not cross.” (EX1004 at 9:31-35). I selected the convolutional code precisely for its convergence properties, that is, each iteration of the iterative detection (feeding of information from the decoder to the demapper) provided enough extrinsic information such that additional iterations would resolve further ambiguous bits. (EX1004 at 1:25-34; 2:30-33; 8:35 to 9:3).

28. This is confirmed by a contemporaneous article I published. The article by Bauch et al. (“*Bauch2*”) is entitled “Turbo Modulation and Coding: Design and Evaluation of Iterative Bit-Interleaved Coded Modulation Methods For Wireless Systems Beyond 3G.” In *Bauch2*, I assessed whether I could improve the performance of the same non-uniquely mapped constellations disclosed in *Bauch* (and relied upon by the Petition) by, rather than using the weaker convolutional

codes described in *Bauch*, using more powerful error correcting codes such as turbo codes or LDPC codes. (EX2017 at 847-848). *Bauch2* states:

Now the question arises, if it makes sense to combine powerful FEC codes such as turbo codes with iterative demapping. More precisely, should we do iterations with the turbo decoder and then feed back extrinsic information to the demapper for a second outer turbo loop. The EXIT curve of a turbo code is close to the curve of an optimum code: It is very steep in the beginning and at the end, but almost horizontal in between. Consequently, the decoder curve crosses the steep curve of a demapper with the optimized mappings which have been proposed above. ***Hence, turbo iterations will not be effective... It can be concluded that turbo optimized mappings should be used with weak outer codes.***

(EX2017 at 848).

V. *Bauch's* Constellation Should Not be Used With LDPC Codes

29. Fundamental to communicating using *Bauch's* non-uniquely mapped constellation is the matching of the error correcting code to the constellation to enable iterative detection to resolve the ambiguous bits of the non-uniquely mapped points. LDPC codes lack this characteristic. (EX1004 at 8:35 to 9:3; 11:6-10). In particular, LDPC codes are too strong, lacking characteristics that enable iterative decoding and demapping to provide an appropriate amount of extrinsic information to pass between the decoder and the demapper at each iteration. As a result, any

attempt to use powerful codes like turbo codes or LDPC codes with *Bauch's* constellation is ineffective.

30. Only weaker codes, such as convolutional codes, which are weaker than LDPC codes but possess suitable convergence characteristics, should be used. In fact, I precisely matched convolutional codes with my non-uniquely mapped constellation because the selected convolutional codes provide appropriate error correction at each iteration such that each additional iteration operates to resolve an additional number of ambiguous bits. As such, only certain codes, such as convolutional codes – not LDPC codes or Turbo codes – are effective to enable error free resolution of ambiguous bits, and by extension, error free decoding and errorless communication. (EX1004 at 1:25-28, 4:27-32, 9:31-35, 11:6-10, 15:7-11, 24:1-3, 26:33-36).

31. That is to say, one should not use the constellations with non-unique mappings that I disclose in my publications with a stronger code such as a turbo code or LDPC code. This is because my constellations require the code to be precisely matched with the constellation in order to achieve error free decoding. Such matching could not be achieved by a stronger turbo code or LDPC code because they do not have the characteristics necessary to allow iterative decoding and demapping to provide the appropriate amount of extrinsic information to pass between the decoder and the demapper at each iteration. As a result, and as I have

published previously, use of the constellations with non-unique mappings with a powerful FEC code such as a turbo code or LDPC code will not be effective. Further, the constellations should be used with a weak code, such as a convolutional code.

VI. The Approach Described in Bauch Creates a Hierarchical System But Was Not Designed for Performance, Improved Bandwidth Efficiency, or Reduced Detection Complexity When Compared to A Traditional Equally Spaced Constellation

A. Iterative Detection Increases Complexity When Compared to An Equivalent System that Does Not Perform Iterative Detection

32. *Bauch* designs constellations that, while achieving a hierarchical system, lowers performance and increases complexity when compared to a system that does not utilize iterative detection. (EX1004 at 13:30-38; 14:19-25; 15:14-23).

33. *Bauch* sacrifices performance and intentionally designs a more complicated system (when compared to a system that does not utilize iterative detection) that treats bit relevance differently. (EX1004 at 13:17-19; 14:34 to 15:3; 15:14-36; 20:28-33). *Bauch's* system is hierarchical and comprises a specially designed constellation of non-uniquely mapped points that are unequally spaced (EX1004 at 13:30-34, 14:19-25, 24:24-32).

B. *Bauch's* Constellation Does Not Provide Improved Performance When Compared to A Traditional Equally Spaced Constellation

34. The constellations I proposed were not designed for capacity performance when compared to a traditional equally spaced constellation. Rather,

we aimed at achieving a flexible hierarchical system enabled by iterative demapping and decoding but which sacrificed performance when compared to a traditional equally spaced constellation with unique mappings. (EX1004 at 13:17-19, 14:34-15:3, 20:28-33).

35. The constellations I proposed were not designed for capacity-achieving performance when compared to a traditional equally spaced constellation. Rather, we aimed for a pragmatic and flexible system, where increased complexity (resulting from iterative detection and when compared to a system that does not utilize iterative detection) is utilized to achieve varying levels of error protection. This scheme sacrificed the objective of performance in order to achieve a hierarchical system.

C. Bauch's Constellation Does Not Provide Improvements in Bandwidth-Efficient Transmission When Compared to A Traditional Equally Spaced Constellation

36. The constellations I proposed were not designed to provide bandwidth efficient transmission when compared to a non-hierarchical and traditional equally spaced constellation. To this end, we sacrificed bandwidth efficiency in order to achieve a flexible hierarchical system.

37. As stated above, *Bauch* deliberately increases system complexity and sacrifices performance (when compared to a system that does not utilize iterative

detection) to provide varying levels of error correction capability. (EX1004 at 13:17-19; 14:34 to 15:3; 20:28-33).

38. *Bauch* describes a scheme that is similar to a hybrid automatic repeat request (HARQ) scheme, however, the incremental redundancy is not separately transmitted over the channel, which would reduce the bandwidth-efficiency. (EX1004 at 14:24-29). Accordingly, the constellations I proposed were not designed to provide more bandwidth efficient transmission when compared to a non-hierarchical and traditional equally spaced constellation.

D. *Bauch's* Constellation Does Not Provide Reduced Detection Complexity When Compared to A System That Does Not Perform Iterative Detection

39. The constellation with non-uniquely mapped points that I proposed require a greater detection complexity when compared to a traditional equally spaced constellation that does not use iterative detection.

40. As established above, iterative decoding and demapping with a convolutional code is central to the use of the constellations of *Bauch*. (EX1004 at 1:25-34, 11:6-10). And while a single pass of a convolutional code decoder has lower complexity than a single pass of a LDPC decoder, iterative decoding and demapping using a LDPC code, when compared to a LDPC decoder that does not require iterative decoding and demapping, represents a substantially higher detection complexity. (EX1004 at 1:25-34, 11:6-10, 14:30-15:23). This is because

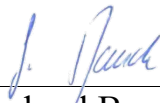
the passing of information from the decoder to the demapper represents a series of complex steps that must be repeatedly performed. (EX1004 at 1:25-34, 11:6-10; 14:30-15:23; EX2017 at 847). Thus, use of *Bauch's* constellations would require higher detection complexity as compared to a traditional equally spaced constellation with unique mappings. (EX1004 at 1:25-34, 11:6-10; 14:30-15:23; EX2017 at 847).

41. The constellation with non-unique mappings that I proposed would require a greater detection complexity when compared to a traditional equally spaced constellation with unique mappings using the same error correcting code. This is because fundamental to using my constellation is the use of iterative decoding and demapping to resolve the ambiguous bits. But because the complexity of my detection scheme arises from the number of iterations between the decoder and the demapper during iterative detection, use of my constellation would require a higher detection complexity when compared to an equally spaced constellation with unique mappings using the same error correcting code.

42. This is confirmed by *Bauch2*, which states “the complexity of the detection scheme is mainly determined by the iterations rather than the components within one iteration.” (EX2017 at 847).

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and 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 Title 18 of the United States Code.

Dated: April 14, 2023



Dr. Gerhard Bauch