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571-272-7822

Paper 17
Entered: February 11, 2021

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TETRA TECH CANADA INC.,
Petitioner,

v.

GEORGETOWN RAIL EQUIPMENT COMPANY,
Patent Owner.

IPR2019-01581
Patent 8,081,320 B2

Before HUBERT C. LORIN, JENNIFER S. BISK, and KRISTINA M. KALAN, *Administrative Patent Judges*.

BISK, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Determining all Challenged Claims Unpatentable
35 U.S.C. § 318(a)

I. INTRODUCTION

Tetra Tech Canada Inc. ("Petitioner") filed a Petition requesting an *inter partes* review of claims 1–17 of U.S. Patent No. 8,081,320 B2 (Ex. 1001, "the '320 patent"). Paper 1 ("Pet."). Georgetown Rail Equipment Company ("Patent Owner"), identified as the owner of and real party in interest to the '320 patent (Paper 5, 2), did not file a Preliminary Response. We instituted this review as to all challenged claims. Paper 6 ("Inst. Dec.").

Subsequent to institution, Patent Owner filed a Patent Owner Response. Paper 8 ("PO Resp."). Petitioner filed a Reply. Paper 9 ("Reply"). Patent Owner also filed a Sur-Reply. Paper 11 ("Sur-Reply"). A transcript of the oral hearing held on December 3, 2020, has been entered into the record as Paper 16 ("Tr.").

This Final Written Decision is entered pursuant to 35 U.S.C. § 318(a). For the reasons that follow, Petitioner has demonstrated by a preponderance of the evidence that claims 1–17 of the '320 patent are unpatentable.

A. Related Matters

The parties identify a district court case in which the '320 patent was previously asserted, but later was withdrawn from the proceeding. Pet. 5; Paper 5, 2. Petitioner adds that related patents, U.S. 7,616,329 (the "'329 patent") and U.S. 9,441,956 (the "'956 patent") remain in that proceeding. Pet. 5. In addition, Canadian national stage entries of the '320 and '329 patents were the subject of Canadian litigation. Pet. 4. Finally, Petitioner notes that both the '329 and '956 patents, as well as related patent U.S. 8,209,145, are the subject of petitions for *inter partes* review. *Id.* at 5 (citing IPR2019-00619, IPR2019-00620, IPR2019-00662, and IPR2019-01409).

B. The '320 Patent

The '320 patent, titled "Tilt Correction System and Method for Rail Seat Abrasion," issued December 20, 2011. Ex. 1001, codes (45), (54). The '320 patent relates generally to inspecting railroad surfaces. *Id.* at 1:26–29. In particular, the '320 patent addresses the problem of rail seat abrasion, which is wear at the point of a railroad track where the two parallel rails are attached to the crossties. *Id.* at 1:52–59. According to the '320 patent, previous methods of measuring and monitoring this wear "have proved either unreliable, hazardous, labor-intensive, requiring extensive equipment installation, or having a major impact on the availability of railroads to train traffic." *Id.* at 2:6–12.

In response to these difficulties, the '320 patent describes a railroad inspection vehicle with mounted lasers, cameras, and processors that take precise measurements of the height of the rail and the tie. *Id.* at 2:22–43. The '320 patent then describes "adjusting these measurements for any expected tilt encountered." *Id.*

The '320 patent describes an example of determining the wear of the rails using image data. Figures 7A and 7B are reproduced below.

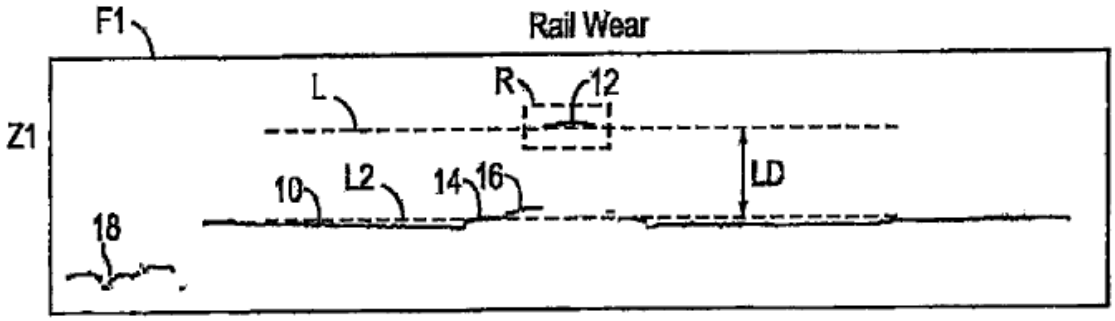

FIG. 7A

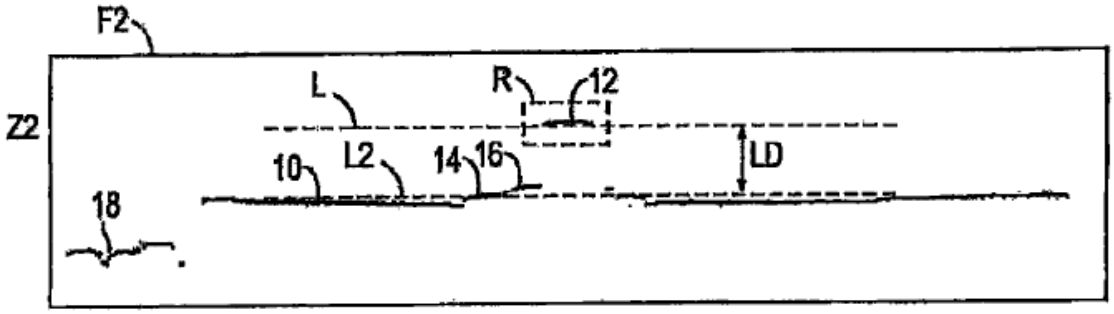

FIG. 7B

Figures 7A and 7B, above, "illustrate example [image data] frames of railroad track obtained with the disclosed inspection system for determining wear of the rail." *Id.* at 3:4–6. Figure 7A shows frame F1 at position Z1 along the track, and Figure 7B shows frame F2 at position Z2. *Id.* at 9:35–39, 9:43–44, 9:51–52. Each frame shows rail 12 lying within a region of interest R and at level L above reference level L2, which may be the height of a tie plate—measurement LD. *Id.* at 9:43–48. Figure 7B shows that "[a]t position Z2, the distance LD is less between the contour of the rail 12 and level L2 than at position Z1" and "[t]hus, frame F2 may indicate wear of the rail 12 at the position Z2 along the track." *Id.* at 9:52–55.

Using data such as that shown in Figures 7A and 7B, the '320 patent explains that "rail seat abrasion may be predicted with a high level of accuracy" using "algorithms that adjust for vehicle tilt." *Id.* at 12:49–53. Vehicle tilt occurs when inspection system 30 moves through curves or

bends in the track resulting in "a suspension lean of the system 30" and "the railroad track itself leaning either to the left or right in the field of the cameras." *Id.* at 12:53–59. Figure 17 is reproduced below.

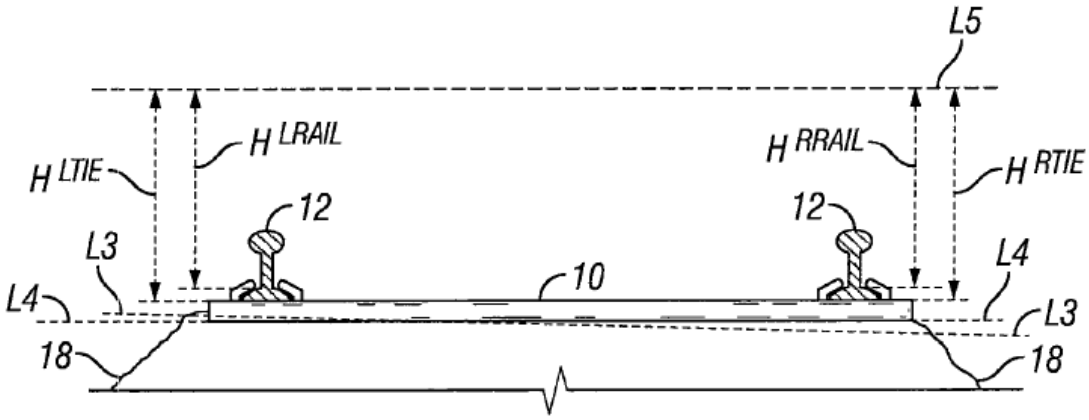

FIG. 17

Figure 17, above, "illustrates a profile image of a rail road track tilted [within a curve] according to an exemplary embodiment of the present invention." Ex. 1001, 3:27–29. In Figure 17, "left and right rails 12 are illustrated laying atop concrete tie 10." *Id.* at 12:66–13:1. "Line L3 represents level ground" and line L4 shows the angular tilt of cross ties 10. *Id.* at 13:1–5. To determine whether rail seat abrasion is present, height measurement of each rail is taken, however, a tilt in the camera may cause one rail to appear higher than another. For example, in Figure 17, because the track is tilting slightly to the left, "the height of right rail 12 would appear taller then left rail 12, resulting in skewed data measurements." *Id.* at 13:5–10. The '320 patent states that empirical and mathematical research has determined that a standard tilt correction factor of 0.12 is incorporated into algorithms to adjust for tilt. *Id.* at 13:11–17. Figure 18, "a flow chart illustrating a method of determining rail seat abrasion," is reproduced below. *Id.* at 3:30–32.

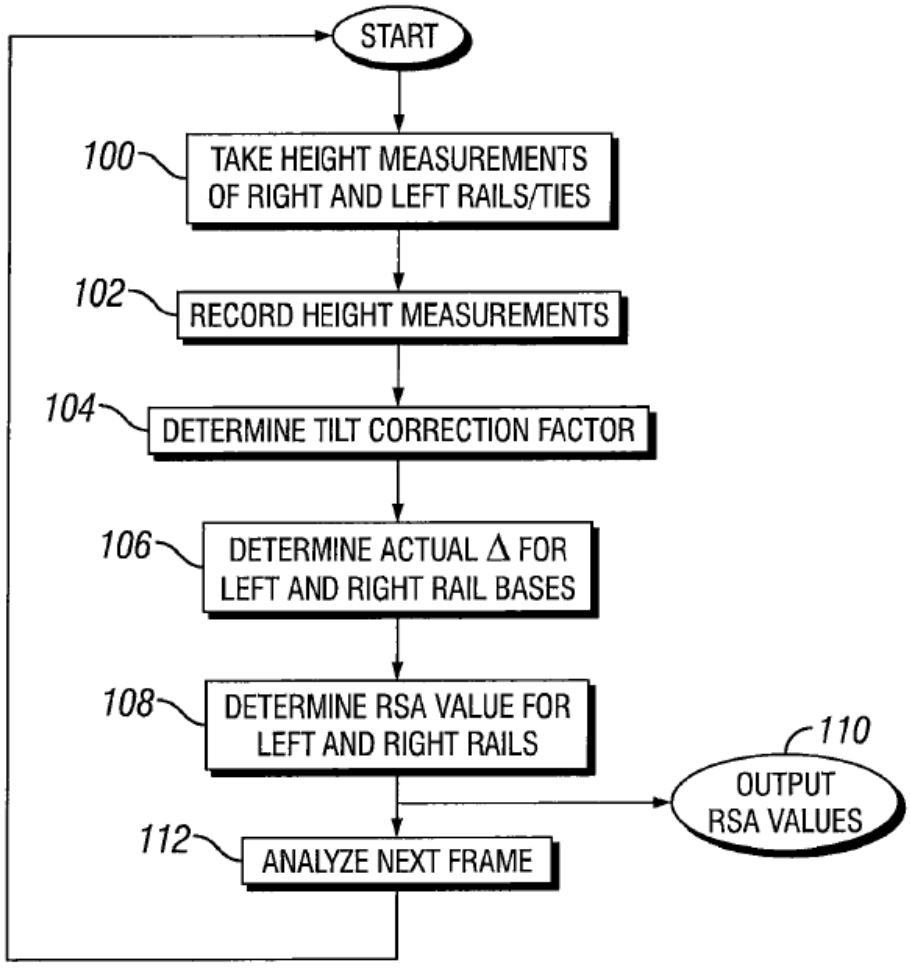

FIG. 18

Figure 18, above, shows a flow chart for a tilt correction algorithm. *Id.* at 13:18–20. Step 100 describes taking measurements of the rail base height of each rail from the image data received from the cameras and, in step 102, the inspection system records those measurements. *Id.* at 13:18–44. In step 104, the inspection system derives the tilt correction factor and step 106 determines the actual difference between the right and left rail bases. *Id.* at 13:45–60. Finally, in step 108, the rail seat abrasion value for the right and left rail bases is determined, after which those values are output

(step 110) and the next frame is analyzed (step 112) using the algorithm starting in step 100. *Id.* at 13:61–14:13.

C. Illustrative Claim

Claims 1, 7, and 12 are independent. Claim 1 is illustrative of the subject matter at issue and reads as follows:

> 1. [preamble] A system for determining rail seat abrasion of a rail road track, the system comprising:
>
> [a] at least one light generator positioned adjacent the rail road track, the light generator adapted to project a beam of light across the rail road track;
>
> [b] at least one camera positioned adjacent the rail road track for receiving at least a portion of the light reflected from the rail road track and for generating at least one image representative of a profile of at least a portion of the rail road track;
>
> [c] at least one processor adapted to perform the steps comprising:
>
> [d] analyzing the at least one image; and
>
> [e] determining whether rail seat abrasion is present along the rail road track,
>
> [f] wherein, when determining whether rail seat abrasion is present, the at least one processor compensates for a tilt of the rail road track.

Ex. 1001, 15:38–55 (bracketing added consistent with Petitioner's analysis of claim limitations "[preamble]–[f]"; *see* Pet. 32–54).

D. Proposed Grounds of Unpatentability

Petitioner asserts the following grounds of unpatentability, each based on 35 U.S.C. § 103(a)[1]:

Claim(s) Challenged	35 U.S.C. §	Reference(s)/Basis
1, 2, 5–7, 10–13, 16, 17	103(a)	Villar,[2] Choros, [3] Casagrande,[4] Szwilski[5]
3, 8, 14	103(a)	Villar, Choros, Casagrande, Szwilski, Khattak[6]
4, 9, 15	103(a)	Villar, Choros, Casagrande, Szwilski, Andersson[7]

Pet. 8, 19–63. Petitioner also relies on the Declaration of Nikos Papanikolopoulos, Ph.D. (Ex. 1004).

Patent Owner disputes each of these grounds of unpatentability and relies on the Declaration of Alan Conrad Bovik, Ph.D. (Ex. 2001) as supporting its position. PO Resp. 4–43.

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[1] Because the application from which the '320 patent issued was filed before March 16, 2013, the effective date of the relevant amendment, he pre-AIA version of § 103 applies. The Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 287–88 (2011), amended 35 U.S.C. § 103.

[2] U.S. 2006/0017911 A1 (published Jan. 26, 2006) (Ex. 1005).

[3] John Choros et al., *Prevention of Derailments due to Concrete Tie Rail Seat Deterioration*, 2007 ASME/IEEE Joint Rail Conference & Internal Combustion Engine Spring Technical Conference (2007) (Ex. 1007, 4–17).

[4] U.S. 2003/0140509 A1 (published July 31, 2003) (Ex. 1008).

[5] WO 2005/036199 A2 (published Apr. 21, 2005) (Ex. 1009).

[6] U.S. 4,899,296 (issued Feb. 6, 1990) (Ex. 1010).

[7] U.S. 5,787,815 (issued Aug. 4, 1998) (Ex. 1011).

II. ANALYSIS

A. Principles of Law

1. *Burden*

"[T]he petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a) (3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")). This burden of persuasion never shifts to Patent Owner. *See Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1378 (Fed. Cir. 2015) (discussing the burden of proof in *inter partes* review).

2. *Obviousness*

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art ("POSITA") to which that subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved based on underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of non-obviousness, if present.[8] *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

[8] Patent Owner has provided no objective evidence of non-obviousness in this case and, thus, we focus our inquiry on the remaining *Graham* factors.

In analyzing the obviousness of a combination of prior art elements, it can be important to identify a reason that would have prompted one of skill in the art "to combine . . . known elements in the fashion claimed by the patent at issue." *KSR*, 550 U.S. at 418. A precise teaching directed to the specific subject matter of a challenged claim is not necessary to establish obviousness. *Id.* Rather, "any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed." *Id.* at 420. Accordingly, a party that petitions the Board for a determination of unpatentability based on obviousness must show that "a skilled artisan would have been motivated to combine the teachings of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success in doing so." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1381 (Fed. Cir. 2016) (internal quotation marks and citations omitted). Under the proper inquiry, "obviousness cannot be avoided simply by a showing of some degree of unpredictability in the art so long as there was a reasonable probability of success." *Pfizer, Inc. v. Apotex, Inc.*, 480 F.3d 1348, 1364 (Fed. Cir. 2007).

We analyze the instituted grounds of unpatentability in accordance with these principles.

3. *Level of Ordinary Skill in the Art*

The level of skill in the art is a factual determination that provides a primary guarantee of objectivity in an obviousness analysis. *See Al-Site Corp. v. VSI Int'l, Inc.*, 174 F.3d 1308, 1323 (Fed. Cir. 1999) (citing *Graham*, 383 at 17–18). The level of skill in the art also informs the claim construction analysis. *See Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 135 S. Ct.

831, 841 (2015) (explaining that claim construction seeks the meaning "a skilled artisan would ascribe" to the claim term "in the context of the specific patent claim" (emphasis omitted)).

Petitioner asserts that a person of ordinary skill in the art "would have a bachelor's degree in electrical engineering, computer engineering, mechanical engineering, computer science, physics, or a related field, and at least four years of experience (or the academic equivalent) in the field of computer or machine vision." Pet. 16–17 (citing Ex. 1004 ¶ 29). Patent Owner "does not contest Petitioner's asserted level of ordinary skill in the art." PO Resp. 1.

Based on our review of the record, we adopt Petitioner's definition of the level of ordinary skill in the art. This level is consistent with that reflected by the references themselves. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001) ("[T]he absence of specific findings on the level of skill in the art does not give rise to reversible error 'where the prior art itself reflects an appropriate level and a need for testimony is not shown.'").

B. Claim Construction

For petitions filed on or after November 13, 2018, such as the one in this case, we interpret claims in the same manner used in a civil action under 35 U.S.C. § 282(b), "including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent." 37 C.F.R. § 42.100(b) (2019). Only terms that are in controversy need to be construed, and then only to the extent necessary to resolve the controversy. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017).

Petitioner does not offer any constructions for any terms of the challenged claims, and indicates that "[t]he terms from the claims of the '320 patent should be given their plain and ordinary meaning." Pet. 17. Patent Owner "agrees with the Petitioner that the '320 patent terms should be given their plain and ordinary meaning." PO Resp. 1. Based on the parties' arguments, however, we discuss the term "standard tilt correction factor."

Claim 4 recites "where the step of determining the tilt correction factor [recited by claim 2] is accomplished based upon the left and right rail base heights and a *standard tilt correction factor*." Ex. 1001, 16:6–9 (emphasis added).

The parties appear to disagree over the construction of "standard tilt correction factor." Petitioner does not explicitly address the construction of this term in the Petition, but does imply a broad construction in its analysis asserting that Andersson discloses the claimed standard tilt correction factor. Pet. 74–75. Consistent with this analysis, in the Reply, Petitioner asserts that "[n]othing in the claim's plain language precludes the standard tilt correction factor from being a sub-category of claim [2]'s tilt correction factor, such as one developed to pre-emptively compensate imaged measurements for known vertical alignment tilt errors associated with upcoming track geometries." Reply 24. Petitioner adds that it would be improper to read into the term the exemplary embodiment of the '320 patent "describing a tilt correction factor incorporated into algorithms to adjust for tilt caused by variations in vehicle suspension, rail height placement stands, and other facts unrelated to rail seat abrasion." *Id.* at 25. Finally, Petitioner asserts that "neither the claim's plain language nor the specification

require[s] applying the same standard tilt correction factor along each section of the track." *Id.*

Patent Owner asserts that the term "standard tilt correction factor" must be different than claim 2's recited "tilt correction factor" based on the plain difference in the wording and claim differentiation. PO Resp. 39; Sur-Reply 24. According to Patent Owner, "standard tilt correction factor" "is not merely based on the simple error in vertical height measurements based on tilt of the railway, but instead factors in 'variations in vehicle suspension' and 'rail height placement standards,' among other 'factors unrelated to rail seat abrasion.'" PO Resp. 40 (citing Ex. 2001 ¶ 121). Further, Patent Owner contends that "the factor is a fixed factor applied to all curves and other parts of the railway" based on the Specification's statement that it is a fixed number—0.12. *Id.*; Ex. 1001, 13:11–15 ("[D]uring significant empirical and mathematical research for the present invention, a standard tilt correction factor of 0.12 was determined. This tilt correction factor is incorporated into algorithms of the present invention in order to adjust for tilt caused by variations in vehicle suspension, rail height placement standards, and other factors unrelated to rail seat abrasion.").

We agree with Patent Owner that, based on the plain and ordinary meaning of the word "standard," the terms "tilt correction factor" and "standard tilt correction factor" are distinct. We, however, do not agree with Patent Owner that the term "standard tilt correction factor" is limited to a fixed factor for all parts of a railway.

A claim term, such as the term "standard" in the claim phrase "a standard tilt correction factor" that is at issue here, bears a "heavy presumption" that the ordinary meaning one skilled in the art would attribute

to said term applies. *See CCS Fitness, Inc. v. Brunswick Corp*., 288 F.3d 1359, 1366 (Fed. Cir. 2002) ("Generally speaking, we indulge a 'heavy presumption' that a claim term carries its ordinary and customary meaning." (citations omitted)). The ordinary meaning of the term "standard" is "something established for use as a rule or basis of comparison in measuring or judging capacity, quantity, content, extent, value, quality, etc. [standard of weight and measure]." Ex. 3001 (Webster's New World Dictionary, Third College Edition, 1306 (1988)), entry 2. We do not see in the ordinary meaning any basis for further qualification that a "standard" must be fixed rather than "variable" as Patent Owner contends.

The ordinary meaning of "standard" can be restricted "if the intrinsic evidence shows that the patentee limited the scope of the claims." *Alloc, Inc. v. Int'l Trade Comm'n*, 342 F.3d 1361, 1377 (Fed. Cir. 2003) (citing, *inter alia*, *Watts v. XL Sys., Inc*., 232 F.3d 877, 882 (Fed. Cir. 2000) ("One purpose for examining the specification is to determine if the patentee has limited the scope of the claims.")). The Specification recites the term "standard" in the context of "a standard tilt correction factor" seven times. Ex. 1001, 13:12, 14:42, 14:64, 15:26, 16:8 (claim 4), 16:36, 17:3. Only at column 13, line 12 is the "standard" further elaborated upon. The other instances simply state "a standard tilt correction factor."

The more detailed discussion of the "standard tilt correction factor" at column 13, line 12 of the Specification relates to an exemplary embodiment that is depicted in Figure 17, reproduced below.

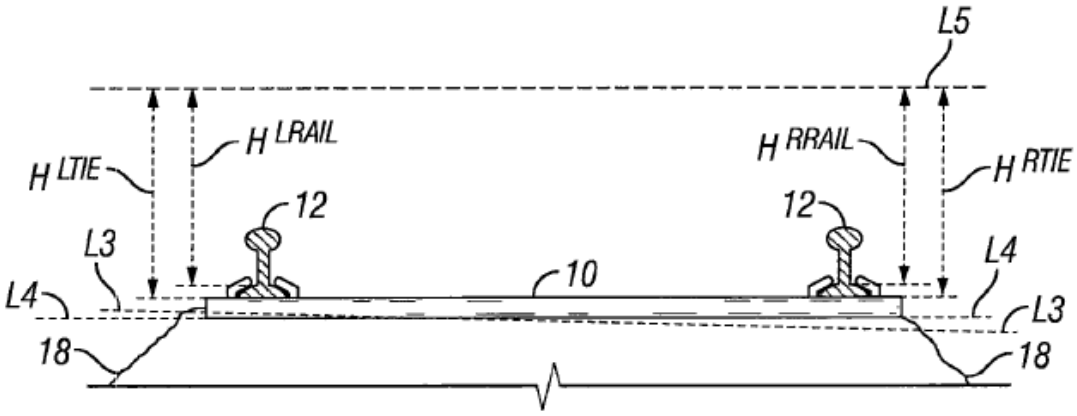


FIG. 17

Figure 17 of the '320 patent "illustrates a profile image of a rail road track tilted according to an exemplary embodiment of the present invention." Ex. 1001, 3:27–29. "[L]eft and right rails 12 are illustrated laying atop concrete tie 10" and "[l]ine L3 represents level ground." *Id.* at 12:66–13:1. This exemplary embodiment represents a curve with an inspection system "moving along the track resulting in an angular tilt of cross ties 10 represented by line L4" such that the track is "tilting slightly to the left." *Id.* 13:1–6. To determine whether rail seat abrasion/deterioration ("RSA") is present, height measurements of both rails 12 must be taken. *Id.* at 13:6–8. Because the height of right rail 12 would appear taller than left rail 12, the resulting data measurements would be skewed. *Id.* at 13:8–10. "Accordingly, during significant empirical and mathematical research for the present invention, a standard tilt correction factor of 0.12 was determined," which "is incorporated into algorithms of the present invention in order to adjust for tilt caused by variations in vehicle suspension, rail height placement standards, and other factors unrelated to rail seat abrasion." *Id.* at 13:11–16.

However, this disclosure does not state that the determined standard

tilt correction factor of 0.12 is used in every embodiment. Instead, this value is tied to the disclosure of Figure 17, which is an "exemplary embodiment." *See id*. at 12:63–67. This example specifically associates the value of 0.12 with, *inter alia*, a track "tilting slightly to the left" (*id.* at 13:5–6) and where the "height of right rail 12 [of Figure 17] would appear taller then [sic] left rail 12" (*id*. at 13:9–10). Claim 4 is not limited to this context. Claim 4 does not mention, for instance, the track tilting to the left. In fact, claim 2, from which claim 4 depends, requires "determining a height of a left rail, right rail" to "compensate[] for the tilt of the rail road track." *Id*. at 15:57–59. Accordingly, claim 4 covers compensating for tilts in other directions.

Patent Owner argues that "[i]t is a 'well-established' principle 'that a claim construction that excludes a preferred embodiment is "rarely, if ever, correct."'" Sur-Reply 25 (quoting *Dow Chem. Co. v. Sumitomo Chem. Co.*, 257 F.3d 1364, 1378 (Fed. Cir. 2001)). However, adopting a broad interpretation of the term "standard tilt correction factor" does not exclude an embodiment using a fixed value for every section of the railway. Instead, such an interpretation would allow for such an embodiment, but would not *limit* the claim to such an embodiment.

Also, limiting claim 4 to read on said exemplary embodiment would necessarily exclude all other values for "a standard tilt correction factor" that claim 4 would otherwise encompass from a plain reading of the claim. But the standard for disavowal of claim scope is exacting. "The patentee may demonstrate intent to deviate from the ordinary and accustomed meaning of a claim term by including in the specification expressions of manifest exclusion or restriction, representing a clear disavowal of claim scope." *Teleflex, Inc. v. Ficosa N. Am. Corp*., 299 F.3d 1313, 1325 (Fed. Cir. 2002).

Here, we do not see expressed in the Specification any intention to restrict the "standard" that one of skill in the art may employ as "a standard tilt correction factor" to practice the claimed subject matter. *Cf. Home Diagnostics, Inc. v. LifeScan, Inc*., 381 F.3d 1352, 1358 (Fed. Cir. 2004) ("Absent a clear disavowal in the specification or the prosecution history, the patentee is entitled to the full scope of its claim language.").

Finally, as to Patent Owner's assertion that the term "standard tilt correction factor" in claim 4 must be different than claim 2's "tilt correction factor" based on the plain difference in the wording and claim differentiation (PO Resp. 39), we agree that claim 4 calls for determining the claim 2 "tilt correction factor" "*based upon* . . . a standard tilt correction factor" and, thus, they must be different in terms of what they represent; that is, the "standard tilt correction factor" is a standard against which the claim 2 "tilt correction factor" is compared. But that does not mean they are different in terms of their values. Their values could match

For the foregoing reasons, we decline to limit "standard tilt correction factor" to a fixed or specific value, as proposed by Patent Owner. Because nothing more specific is needed for analysis of the issue in this Decision, we do not further construe this term.

C. Overview of Prior Art References

1. *Villar*

Villar is titled "System and Method for Inspecting Railroad Track." Ex. 1005, code (54). The named inventors of Villar—Christopher M. Villar, Steven C. Orrell, and John Anthony Nagle, II—are the same as those named in the '320 patent, and both Villar and the '320 patent claim priority to U.S.

provisional application No. 60/584,769, filed June 30, 2004.[9] Ex. 1001, code (60); Ex. 1005 ¶ 1. In fact, Villar and the '320 patent appear to share much of the same written description, and Villar's twelve figures appear to be identical to the first twelve figures of the '320 patent. *Compare* Ex. 1001 Figs. 1–12 and 1:24–10:52 *with* Ex. 1005 Figs. 1–12 and ¶¶ 1–56.

Specifically, Villar describes a system, similar to the '320 patent's railroad inspection vehicle system, with mounted lasers, cameras, and processors that can analyze the captured images to determine various measurable aspects of the railroad track. Ex. 1005 ¶ 8. Villar also describes the example in the '320 patent of determining the wear of rails using image data. Ex. 1005, Figs. 7A, 7B, ¶¶ 17, 50. Villar, however, does not explicitly discuss rail seat abrasion or contain a description of algorithms that adjust for vehicle tilt, as does the '320 patent. *See* Ex. 1001 Figs. 17, 18, 12:49–14:14.

1. *Choros*

a. Overview

Choros is titled "Prevention of Derailments Due to Concrete Tie Rail Seat Deterioration." Ex. 1007, 7. It describes "research on rail seat abrasion/deterioration and methods to measure and prevent derailments." *Id.* Choros describes collecting data using "geometry cars" or inspectors using "an abrasion measurement gauge." *Id.* at 11; *see also id.* at 13 ("As

[9] The '320 patent is a continuation-in-part of application No. 12/465,473, filed on May 13, 2009, which is a continuation-in-part of application No. 11/172,618, filed on June 30, 2005, now Patent No. 7,616,329 (the "'329 patent"). The '329 patent also claims priority to provisional application No. 60/584,769, filed June 30, 2004. U.S. 7,616,329 B2, code (60).

measurement methodologies improve, either from automated inspection vehicles or hand held devices, then the curve given in Figure 9 and values in Table 2 can be adjusted to reflect the new field data.").

Figure 8, reproduced below, shows "rail rotation due to rail seat abrasion . . . for the five possible cases of concrete tie rail seat abrasion that are found in high curvature track." *Id.* at 11.

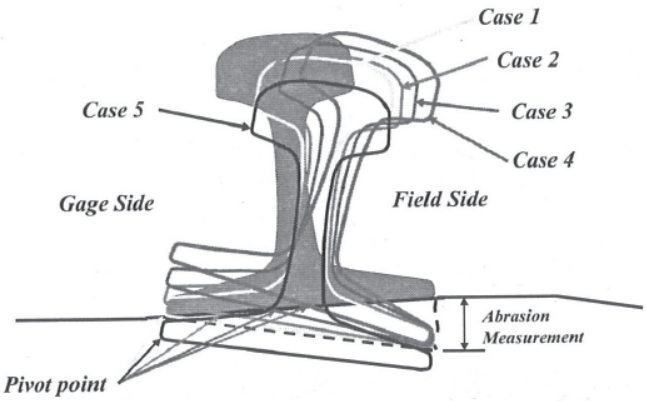


Figure 8. Five possible cases of concrete tie abrasion.

Figure 8, above, shows a rail with the left labeled "Gage Side" and the right labeled "Field Side." *Id.* at 12. It labels five cases (labeled "Case 1" through "Case 5") of potential abrasion measurements taken at the field side between the rail base and the concrete tie, with each case showing an outline of the associated rotation of the rail due to the RSA. *Id.* at 11. "Two readings are required one on each side of the concrete tie as viewed from the field side to the centerline of the track." *Id.* In addition, the label "Pivot point" on the lower left of the rail shows the related pivot point for each of the five cases, and the label "Abrasion Measurement" shows the amount of displacement between the rail and tie. *Id.* at 12.

Table 1 provides a description of each of the five cases shown in Figure 8 (*id.* at 11–12) and Table 2 describes maximum abrasion for various classes of track found on the track safety standards for case 4, the worst case scenario (*id.* at 13–14).

b. Prior Art Status

Patent Owner contends that "[t]he Petition fails to establish that Choros is a printed publication under the patent statute." PO Resp. 2; Sur-Reply 1.

Choros is an article appearing at pages 173 to 181 of a book ("the volume") titled "Proceedings of the ASME//IEEE Joint Rail Conference and the ASME Internal Combustion Engine Division Spring Technical Conference -2007-." Ex. 1007, 5. The cover page of the volume states that the papers were presented at the named conference on March 13–16, 2007 in Pueblo, Colorado. *Id.* The next page of the volume includes the text "ISBM No. 0-7918-4787-X" and "Copyright © 2007 by ASME, All Rights Reserved, Printed in U.S.A." *Id.* at 6. This page also shows a stamp in the upper left corner, "General Library System University of Wisconsin – Madison 728 State Street Madison, WI 53706-1494 U.S.A." *Id.*

The Declaration of Rachel J. Watters, "a librarian, and the Director of Wisconsin TechSearch ('WTS'), . . . an interlibrary loan department at the University of Wisconsin-Madison," includes as Exhibit A an abridged copy of the volume in which Choros appears and as Exhibit B a copy of the cataloging system record for the University's copy of the volume. *Id.* at 1–3 (Watters Declaration), 17 (Exhibit B cataloging system record); *see also* Pet. 7 (noting that Choros includes the "Declaration of Rachel J. Watters on Authentication of Publication"). Ms. Watters describes the standard

operating procedures for materials at the University of Wisconsin-Madison Libraries and states that the University "had [Choros] cataloged in the system as of July 11, 2007." *Id.* at 2 (citing Ex. 2007, 17). According to Ms. Watters, "[m]embers of the interested public could have located [Choros] after it was cataloged by searching the public library catalog or requesting a search though WTS . . . by title, author, and/or subject key words." *Id.* Ms. Watters further explains that such interested member of the public "could access the publication by locating it on the library's shelves or requesting it from WTS." *Id.*

Patent Owner argues that the Petition's citation to the Declaration of Rachel J. Watters is an improper incorporation by reference that does not satisfy the requirement to "include 'a detailed explanation of the significance of the evidence.'" *Id.* (quoting 37 C.F.R. § 42.22(a)). We do not agree that the Petition improperly incorporates the Watters declaration by reference. Instead, the Petition properly relies on the Watters Declaration to support its contention that Choros is a printed publication. Although the Petition's discussion of the issue is succinct, and reference to the Watters Declaration is in a parenthetical citation, we are not persuaded that any more was necessary. The Watters Declaration consists of two pages of straightforward testimony supporting Petitioner's uncomplicated position that Choros was published in 2007 and, therefore, no further explanation was necessary prior to any dispute on this issue.

Patent Owner also contends that the Petition fails "to prove that Choros was publicly accessible." PO Resp. 2; Sur-Reply 2. Specifically, Patent Owner argues the "declaration does not indicate how a POSITA could locate Choros prior to the critical date by exercising reasonable diligence."

PO Resp. 3. According to Patent Owner, the declaration describes how a member of the interested public could locate the overall proceedings, but not specifically how they would locate Choros, which is just a portion of the proceedings. *Id.*; Sur-Reply 2–3. Patent Owner adds that the catalog record similarly refers to the entire proceedings as opposed to the article at issue. PO Resp. 4; Sur-Reply 3.

We have reviewed the evidence and find that it weighs in favor of Petitioner's position. If one of ordinary skill in the art would have been able to locate "the volume" containing Choros upon exercising reasonable diligence, then one of ordinary skill in the art would have been able to locate Choros within said volume upon exercising reasonable diligence. As Patent Owner points out, "the ultimate question is whether the reference was available to the extent that persons interested and ordinarily skilled in the subject matter or art, exercising reasonable diligence, can locate it." Sur-Reply 2 (quoting *Acceleration Bay, LLC v. Activision Blizzard Inc.*, 908 F.3d 765, 774 (Fed. Cir. 2018)).

Moreover, Ms. Watters's testimony credibly supports Petitioner's assertion of the public accessibility of Choros as of the critical date. There is no dispute that a POSITA would have been able to locate "Proceedings of the ASME//IEEE Joint Rail Conference and the ASME Internal Combustion Engine Division Spring Technical Conference -2007-," which includes Choros, by exercising reasonable diligence. Ms. Watters specifically refers to "an excerpt of pages 173 to 181 of that volume" (i.e., Choros). Ex. 1007, 2. Her reference to pages 173 to 181 as being included in the volume persuades us that the 2007 date stamp on the title page of the volume applies to Choros.

Furthermore, we observe that the page after the cover page indicates that the volume was published by the ASME Technical Publishing Department. Ex. 1007, 6. This page also includes the text "ISBM No. 0-7918-4787-X" and "Copyright © 2007 by ASME, All Rights Reserved, Printed in U.S.A.," as well as directions for obtaining authorization to use the material outside of the fair use provisions of the Copyright Act. *Id.* The cover page indicates that the papers contained in the volume were presented at a joint ASME/IEEE conference in 2007. *Id.* at 5. "Exhibit 1007 indicates that ASME is a substantial organization engaged in a host of professional activities such as organizing conferences and publishing volumes of professional work." Taken together, these indicia strongly suggest that Choros was published by an established publisher. "[W]hen there is an established publisher there is a presumption of public accessibility as of the publication date." *VidStream LLC v. Twitter, Inc.*, 981 F.3d 1060, 1065 (Fed. Cir. 2020).

Accordingly, Petitioner has established that Choros is a printed publication by a preponderance of the evidence.

2. *Casagrande*

Casagrande is titled "Apparatus for Monitoring the Rails of a Railway or Tramway Line." Ex. 1008, code (54). It describes "[a] laser apparatus for monitoring the rails of a railway or tramway line" mounted on a railway carriage to monitor wear of the rail. *Id.* at code (57), ¶ 9. The measurement devices described by Casagrande are able to gather data that allow the processor unit to calculate various parameters of the track, including the gauge, the radius of curvature, the horizontal alignment, the vertical alignment, and the skew. *Id.* at Fig. 5, ¶¶ 30–35.

Figure 6 of Casagrande is reproduced below.

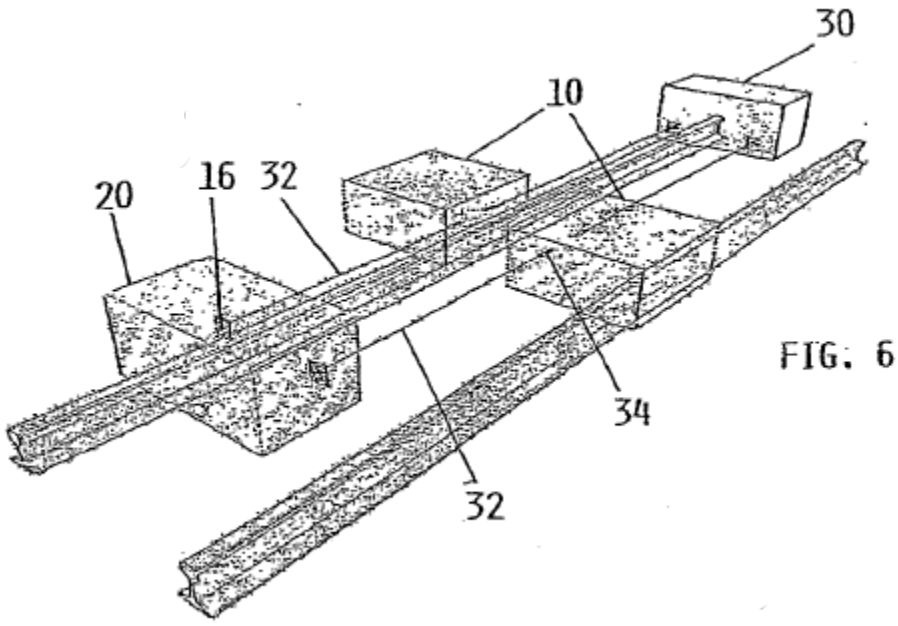


FIG. 6

Casagrande states that:

> FIG. 6 shows schematically the principle of compensation for the errors due to elastic deformation of the railway or tramway carriage. With this, the position in height of each triangulation reading device located in the two end measurement units 20 and 30 is monitored by a laser bar 32 emitted by a source 34 positioned in the central measurement unit 10 and received by a sensor 16 positioned in the end measurement unit 20, 30 and able to constitute a precise alignment of the points of measurement. Lack of alignment results in a signal which by means of suitable software is able to automatically compensate the resultant measurement errors.

Ex. 1008 ¶ 36.

3. *Szwilski*

Szwilski is titled "Railroad Surveying and Monitoring System."

Ex. 1009, code (54). It discloses a system mounted on a mobile platform for "surveying, monitoring, and analyzing rail position and superstructure and

terrain substructure of railroad tracks or other structures" to "monitor track displacements during track inspection in real time." *Id.* at code (57). Szwilski states: "Position data of the rail will not be accurate if there is inclination of the track 120a, b, unless the vertical error 310 and the horizontal error 312 is accounted for." *Id.* at 18.[10] Figure 3, reproduced below, "shows a cross-section view of a preferred mobile platform 102 and demonstrates the vertical error 310 and horizontal error 312 due to track inclination." *Id.*

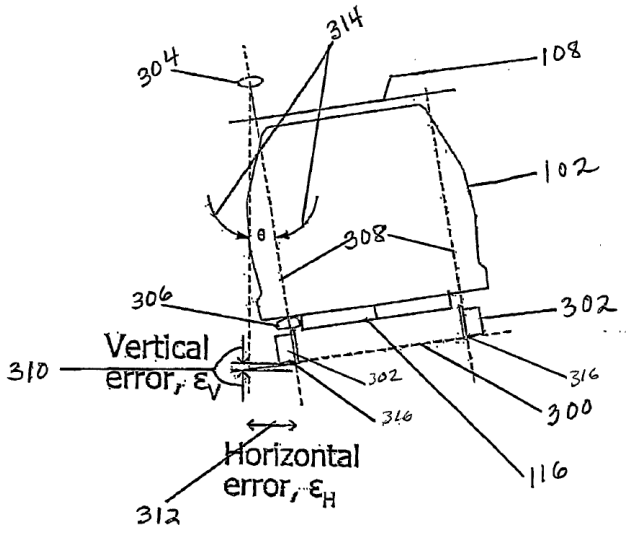


Figure 3

Figure 3 shows "track inclination angle Θ 314 of the cross level 300 of the track 120a,b," which "can be determined by basic application of trigonometry." *Id.* at 18. On the left side of Figure 3, 310 is labeled "Vertical error, ε_v" and 312 is labeled "Horizontal error, ε_H" due to track inclination or lift. *Id.* at Fig. 3. Figure 3 also shows mobile platform 102 comprising wheels 302 to roll along rails 120a,b, of the track. Szwilski

[10] For purposes of this Decision, we refer to the page numbers on the bottom left of Exhibit 1009.

discloses that the system can be used for "determining rail displacement 234 or other rail 120a,b defects and for even non-railroad applications." *Id.* at 22.

D. Obviousness Analysis

1. *Combining Villar with Choros*

Each of Petitioner's contentions relies on the combination of Villar and Choros, along with other references. The Petition asserts that a person of ordinary skill in the art would have been motivated to implement Villar's automated railroad track inspection vision system with Choros's method of measuring RSA because such automated system would "provide important, reliable, and objective performance measures of crosstie health, for addressing and correcting (or renewing) crossties" and "allow for more frequent measurement of critical track parameters while avoiding the issues associated with manual inspection." Pet. 25–26 (citing ex. 1004, ¶ 42). According to Petitioner, "automating manual inspection tasks has been the target of extensive research efforts and sensing methodologies for railroad inspection" and other domains "well before the '320 patent to 'achieve a high inspection rate and high reliability in inspection.'" *Id.* at 26 (quoting Ex. 1026, 545–546) (citing Ex. 1026, 73, 107, 248–250, 361, 406; Ex. 1027; Ex. 1028, 5; Ex. 1025, 15; Ex. 1029, 18; Ex. 1030, 9; Ex. 1031, 2; Ex. 1032, 1:13–29; Ex. 1033, 6; Ex. 1034, 3; Ex. 1004 ¶ 42).

Petitioner also explains that "following two high profile derailments in 2005 and 2006, the Federal Railroad Administration ('FRA') made automated RSA identification a priority and a standard for . . . determining whether RSA is present along a railroad track." *Id.* at 27 (citing Ex. 1016, 1–2; Ex. 1040; Ex. 1041, 2–6; Ex. 1021, 19; Ex. 1020, 81). Petitioner

explains that combining Villar and Choros, thus, "is further to and consistent with rules promulgated to the railroad industry by the Federal Government at the relevant time." *Id.* (citing Ex. 1004, ¶ 43).

Petitioner provides testimony from Dr. Papanikolopoulos that "automation would also yield more meaningful and accurate top height contour and other geometric information about the measured rail and tie components" and "[i]t was well-known before 2009 to use vehicle-mounted automated machine vision systems to quickly identify, inspect, assess, and evaluate the condition and alignment of railroad track components, including rails and ties." *Id.* (quoting Ex. 1004 ¶ 44). According to Petitioner, it was also well-known at the time to use machine vision systems "to generate and analyze images of inspected objects to ascertain and extract more accurate determinations of an object's geometric properties, including the height of the object, for identifying defective components" and using such systems "had become the standard." *Id.* at 27–28 (citing Ex. 1004 ¶ 44; Ex. 1028, 5; Ex. 1025, 15; Ex. 1039, 18; Ex. 1019, 6; Ex. 1031; Ex. 1024).

Finally, Petitioner points to Choros's description of using geometry cars to collect pertinent data (Ex. 1007, 11, 13) and Villar's recognition of using its inspection system to determine track component defects (Ex. 1005, ¶¶ 8, 23, 43, 47, 50, 52, claims 1, 15, 23) as providing evidence that a person of ordinary skill in the art would combine the two references as proposed. *Id.* at 28–29 (citing Ex. 1004 ¶¶ 45–46).

Patent Owner argues that a person of ordinary skill in the art would not have combined Villar's complex machine vision system with Choros's manual method of measuring railroad track features. PO Resp. 4–6; Sur-Reply 4. According to Patent Owner, "implementing even the simplest

concept into computer vision is a difficult and extremely time-consuming process" and "creating a 'machine vision system with a specific feature, especially a new feature, is difficult and generally is not an obvious endeavor.'" PO Resp. 5 (quoting Ex. 2001, ¶ 38). Patent Owner, thus, concludes that it would not have been obvious to implement the manual measurement of rail seat abrasion as disclosed by Choros in a computer vision system, like Villar. *Id.* at 6 (citing Ex. 2001, ¶ 40), 9–10.

Patent Owner further argues that automating Choros's measuring system is not a sufficient reason to combine Villar and Choros. *Id.* at 14–15 (citing Ex. 2001, ¶ 61). According to Patent Owner, the FRA rules do not provide motivation to combine the references because they "did not come into effect until November 8, 2011, over two years after the '320 patent's effective filing date. *Id.* (citing Ex. 1017, 1); Sur-Reply 9–10. In addition, Patent Owner argues "the FRA expressly recognized that existing automated and manual technologies were sufficient to satisfy those rules" and also clarified that the rules require visual verification by inspectors. PO Resp. 14 (citing Ex. 1017, 3–4; Ex. 2001, ¶ 62); Sur-Reply 10.

Finally, Patent Owner argues that "Villar expressly teaches away from the manual measurement and visual inspection disclosed in Choros." *Id.* at 10 (quoting Ex. 2001, ¶ 55); Sur-Reply 7–8. Patent Owner notes that Villar explains its invention overcomes the time consuming aspect of visual inspection by human inspectors by automating the process. PO Resp. 10–11 (citing Ex. 1005, ¶¶ 4, 8; Ex. 2001, ¶ 55). Patent Owner also contends that Choros discloses that "automated geometry car systems, can, at best, detect potential locations where RSA might exist, but to determine if there is RSA, and to measure RSA, requires that a track inspector must subsequently visit

those locations to view and physically measure RSA at each rail set on each crosstie." *Id.* at 13 (citing Ex. 1007, 11; Ex. 2001, ¶ 59). According to Patent Owner, Villar therefore teaches away from Choros's manual measurement and visual inspection method. *Id.* at 11–13 (citing Ex. 1007, 11–13; Ex. 2001, ¶ 56).

The evidence of record supports Petitioner's position that a person of ordinary skill in the art would have found it obvious to combine Villar's automated railroad track inspection vision system with Choros's method of measuring RSA. We credit the testimony of Dr. Papanikolopoulos that, at the relevant time, because of the significant benefits over human inspection and measurement, technology advances had made standard the use of automated systems to identify and assess the condition of defective physical components across many industries. Ex. 1004, ¶¶ 42–44. This testimony is supported by objective evidence. For example, Dr. Papanikolopoulos references documents discussing the use of three-dimensional machine vision for measuring various surface shapes. *See*, *e.g.,* Ex. 1023 (US patent issued in 2002 describing inspection of objects with a moving inspection device using image processing); Ex. 1025, 15 (dissertation dated 1995 discussing the use of image processing for "road surface surveying"); Ex. 1026 (book published in 1987 describing three-dimensional machine vision including for inspecting solder joints of printed circuit boards); Ex. 1032 (US patent issued in 2006 describing an image-processing unit for obtaining three-dimensional images of objects in carriers); Ex. 1035 (1994 article surveying automated visual inspection systems and techniques). Dr. Papanikolopoulos also points to objective evidence that such technology advances in other industries often translate to similar advances in track

inspection. Ex. 1004, ¶ 44 (quoting Ex. 1019, 6 (2006 presentation to American Railway Engineering and Maintenance-of-Way Association)). Dr. Papanikolopoulos also testifies that a person of ordinary skill in the art at the relevant time could have easily combined the teachings of Villar and Choros, "and doing so would have yielded nothing more than predictable results." *Id.* ¶ 48.

We give less weight to Dr. Bovik's broad, conclusory testimony to the contrary that "it generally would not be obvious to a POSITA to combine a task or technique performed [manually without machine vision] with a prior art reference that discloses the use of machine vision, unless the vision system already performs that task or technique." Ex. 2001, ¶ 39. Not only is this testimony inconsistent with the extensive evidence relied upon by Dr. Papanikolopoulos showing rapid developments in machine vision techniques across many industries, it is not supported by objective evidence. *See id.* ¶¶ 37–40; *see also* Sur-Reply 4 (stating Dr. Bovik's "background provides 'support' for his opinions"). "Lack of factual support for expert opinion going to factual determinations, however, may render the testimony of little probative value in a validity determination." *Ashland Oil, Inc. v. Delta Resins & Refractories, Inc.*, 776 F.2d 281, 294 (Fed. Cir. 1985).

We also credit the evidence that FRA Rules promulgated in 2011 demonstrate motivation to automate the identification of RSA. Although these rules were published in final form after the 2009 effective filing date of the '320 patent, the record contains evidence that the industry was discussing the importance of RSA detection as early as 2008. *See* Ex. 1021, 19 (draft minutes of 2008 meeting of the Railroad Safety Advisory Committee). Whether or not the rules on the issue were finalized, the issue

of the detection of RSA was clearly of interest to the industry and the benefits of automation of such detection was clear. *See, e.g.*, Ex. 1019; Ex. 1021; Ex. 1035. The fact that the FRA recognized that the final rules could be satisfied using existing technology, which included both manual and automated inspection (Ex. 1017, 3–4; Ex. 2001, ¶ 62), does not diminish the importance of the issue to the industry and would not discourage innovation in the detection of RSA.

Finally, the evidence of record does not support a finding that Villar teaches away from the disclosure of Choros. We agree with Patent Owner that Villar explains that "visual inspection is quite time consuming" and its disclosed invention overcomes this problem by automating the process. Ex. 1006, ¶¶ 4, 8. However, instead of teaching away from Choros's manual measurement method as a candidate for automating Villar's system, Villar's disclosure provides encouragement to make such a combination. *See* Reply 9–10. In fact, Villar states that "[a] number of measurable aspects of the railroad track can be determined or detected from the image data of the track bed with the disclosed inspection system and associated methods" and "other techniques known in the art for analyzing the image data can be used with the disclosed inspection system and associated methods." Ex. 1005, ¶ 43. Although Patent Owner dismisses this language as "boilerplate language" that "cannot enlarge Villar beyond what its specification describes" (Sur-Reply 8), we agree with Petitioner that this language is explicit motivation to automate Villar's system with known methods of visual measurement, such as disclosed in Choros.

As for Choros's discussion of collecting data using geometry cars, we agree with Petitioner that this indicates automation may provide benefits to

detecting RSA. Choros explicitly states that "[d]ata collected on geometry cars is considered as an alternative method for identifying critical locations." Ex. 1007, 11. Although this does not disclose a complete method for measuring and detecting RSA, it does provide a suggestion to a person of ordinary skill in the art that automation of the process is beneficial. Choros also notes that the limited availability of existing geometry cars may not allow for the necessary frequency of inspections. *Id.* This acknowledgement, however, does not indicate that automated RSA detection is not technically feasible or should be avoided. *In re Gurley,* 27 F.3d 551, 553 (Fed Cir. 1994) ("A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant. The degree of teaching away will of course depend on the particular facts; in general, a reference will teach away if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the applicant."). Given the well-known benefits of automated inspections over visual inspections, we see no reason that a lack of availability of geometry cars at a particular point in time would dissuade a person of ordinary skill in the art from pursuing automation of RSA detection.

Based on the evidence of record, we find that a person of ordinary skill in the art would have found it obvious to combine Villar's automated railroad track inspection vision system with Choros's method of measuring RSA.

2. *Independent Claim 1*

Petitioner contends that claim 1 would have been obvious over the combined disclosures of Villar, Choros, Casagrande, and Szwilski. Pet. 32–54. Petitioner relies on Villar for teaching or suggesting the preamble and limitations (a) through (d) of claim 1. Pet. 32–37.

a. limitation 1(preamble): "a system for determining rail seat abrasion of a rail road track"

The preamble of claim 1 recites "a system for determining rail seat abrasion of a rail road track." Ex. 1001, 15:38–39. Petitioner asserts that the combined disclosures of Villar and Choros discloses such a system. Pet. 32–34. Specifically, Petitioner explains that Villar discloses an inspection system for inspecting a railroad track that measure the height of track components. *Id.* at 32 (citing Ex. 1005, Figs. 1, 2, ¶ 23, claims 1, 15, 23). In addition, Petitioner points to Choros as disclosing the use of a measurement gauge to determine RSA "by measuring a vertical distance between a top surface of rail base and a top surface of the cross tie adjacent the rail." *Id.* at 33 (citing 1007, 7–9, 11–12, Figs. 7, 8). Finally, Petitioner asserts that it would have been obvious to a person of ordinary skill in the art to "implement Villar's automated railroad track inspection vision system with Choros's method of measuring RSA . . . to automatically determine whether RSA is present along a railroad track." *Id.* at 33–34 (citing Ex. 1004, ¶ 54).

Based on the record, we are persuaded by Petitioner's showing that Villar and Choros teach or suggest a system for determining rail seat abrasion of a rail road track. Accordingly, we determine that Petitioner has

established by a preponderance of the evidence that Villar and Choros teach the preamble of claim 1. [11]

b. limitation 1(a): "at least one light generator positioned adjacent the rail road track, the light generator adapted to project a beam of light across the rail road track"

Claim 1 recites "at least one light generator positioned adjacent the rail road track, the light generator adapted to project a beam of light across the rail road track." Ex. 1001, 15:40–42. Petitioner asserts that Villar discloses this limitation. Pet. 34. Specifically, Petitioner asserts that Villar's inspection system 30 includes a light generator, such as a laser 40, which projects a beam 42 of laser light at the track bed, which in turn produces a projected beam of light L that follows the contours of the surfaces and track bed components. *Id.* (citing Ex. 1005, Figs. 1–2, ¶¶ 23, 25, 28, claims 1, 15).

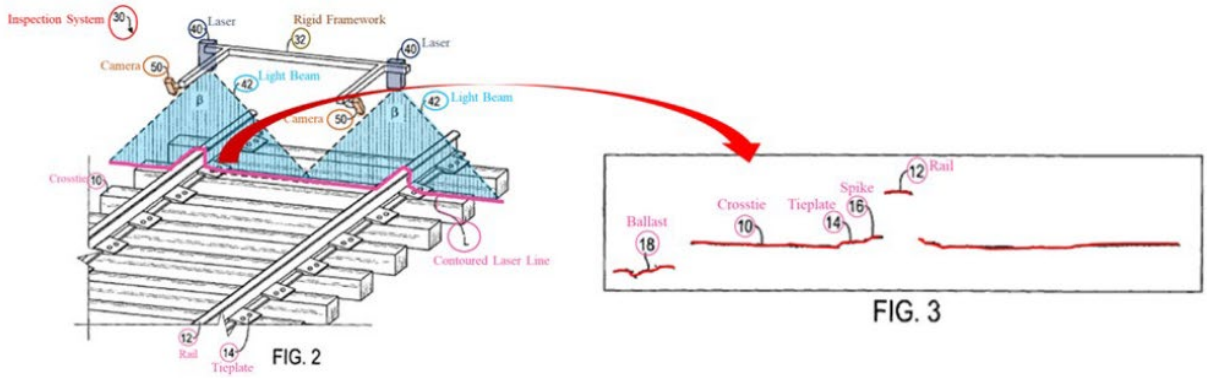
Based on the record, we are persuaded by Petitioner's showing that Villar teaches or suggests at least one light generator positioned adjacent the rail road track, the light generator adapted to project a beam of light across the rail road track. Patent Owner does not dispute Petitioner's contentions regarding this limitation. *See* PO Resp. 6–31. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that Villar teaches or suggests limitation 1(a).

[11] In light of this finding, we need not reach whether claim 1's preamble is limiting.

c. *limitation 1(b): "at least one camera positioned adjacent the rail road track for receiving at least a portion of the light reflected from the rail road track and for generating at least one image representative of a profile of at least a portion of the rail road track"*

Claim 1 recites "at least one camera positioned adjacent the rail road track for receiving at least a portion of the light reflected from the rail road track and for generating at least one image representative of a profile of at least a portion of the rail road track." Ex. 1001, 15:43–47.

Petitioner asserts that Villar discloses this limitation. Pet. 34–35. For explanatory purposes, Petitioner creates annotated versions of Figures 2 and 3 of Villar, which are reproduced below.



Villar, FIGS. 2, 3 (annotated).

Pet. 35. Annotated Figure 2 shows "a portion of an embodiment of a system for inspecting railroad track[s]." Ex. 1005 ¶ 12. Figure 2 shows lasers 40 that project beam 42 of light in a "projected line L that is substantially straight and extends substantially across the track bed" (Petitioner annotates line L in fuchsia). *Id.* ¶ 28; Pet. 35. "[C]ameras 50 are positioned adjacent the lasers 40" and "capture an image or frame of the track bed at small, regular increments," which image is "then filtered and processed to isolate the contoured laser line L projected on the track bed." *Id.* ¶¶ 30–31.

Cameras 50 "send image data directly to the processing device or computer 60 via transmission lines." *Id.* ¶ 32. Figure 3 shows "an example frame of a portion of railroad track obtained with the disclosed inspection system." Ex. 1005, ¶ 13.

Specifically, Petitioner relies on Villar's camera 50 as positioned adjacent the railroad track and generating an image representative of the profile of the scanned portion of the railroad track. Pet. 35 (citing Ex. 1005, Figs. 2–3, ¶¶ 24, 28, 30, 32, 35).

Based on the record, we are persuaded by Petitioner's showing that Villar teaches or suggests at least one camera positioned adjacent the rail road track for receiving at least a portion of the light reflected from the rail road track and for generating at least one image representative of a profile of at least a portion of the rail road track. Patent Owner does not dispute Petitioner's contentions regarding this limitation. *See* PO Resp. 6–31. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that Villar teaches or suggests limitation 1(b).

d. limitation 1(c): "at least one processor adapted to perform the steps"

Claim 1 recites "at least one processor adapted to perform the steps." Ex. 1001, 15:48–49. Petitioner asserts that Villar discloses this limitation. Pet. 36–37. For explanatory purposes, Petitioner creates an annotated version of Figure 1 of Villar, which is reproduced below.

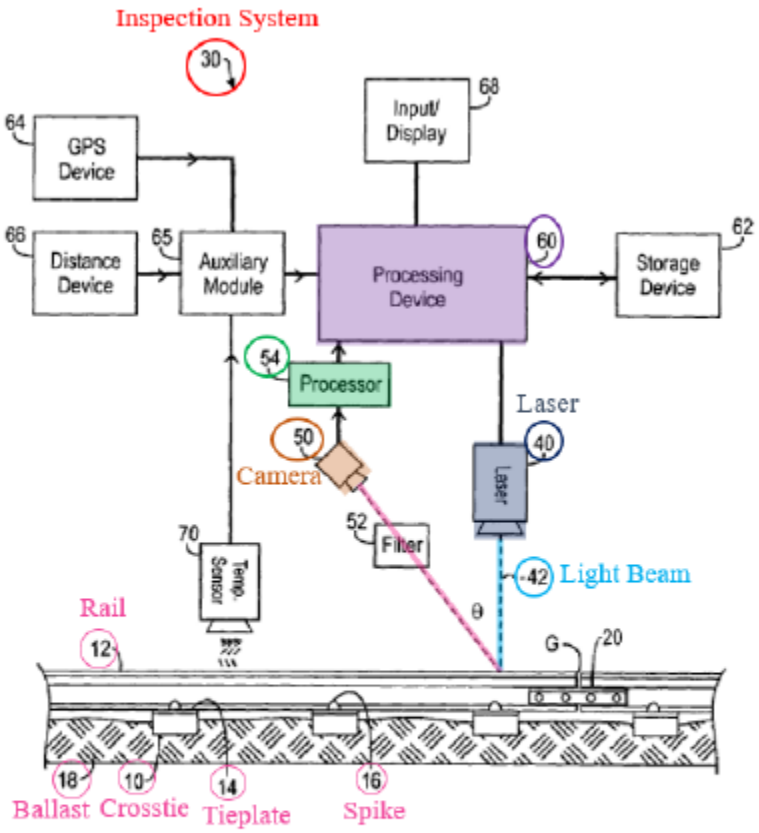


FIG. 1

Villar, FIG. 1 (annotated).

Pet. 36. Annotated Figure 1 shows "an embodiment of the disclosed inspection system." Ex. 1005 ¶ 11. Figure 1 shows processor processing device 60 (annotated to be purple), which receives image data from cameras 50 (annotated to be orange). *Id.* ¶¶ 24, 32; Pet. 36. "[P]rocessing device or computer 60 includes a microprocessor, inputs, outputs, and a data storage device 62," "can further include an input/display 68," and "operates with suitable software programs for storing and analyzing the various data obtained with the disclosed inspection system 30." Ex. 1005 ¶ 33.

Specifically, Petitioner relies on Villar's processing device 60 as teaching or suggesting at least one processor adapted to perform the steps. Pet. 36 (citing Ex. 1005, Fig. 1, ¶¶ 8, 24, 33–34, 46, 49).

Based on the record, we are persuaded by Petitioner's showing that Villar teaches or suggests at least one processor adapted to perform the steps. Patent Owner does not dispute Petitioner's contentions regarding this limitation. *See* PO Resp. 6–31. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that Villar teaches or suggests limitation 1(c).

e. limitation 1(d): "analyzing the at least one image"

Claim 1 recites "analyzing the at least one image." Ex. 1001, 15:50. Petitioner asserts that Villar discloses this limitation. Pet. 37. Specifically, Petitioner states that Villar's "processing device 60 operates with any suitable image processing software for storing and analyzing various image data obtained with the inspection system 30 and performing steps determining the defects in the components of the railroad track." *Id.* (citing Ex. 1005, ¶¶ 8, 33–34, 46, 49).

Based on the record, we are persuaded by Petitioner's showing that Villar teaches or suggests analyzing the at least one image. Patent Owner does not dispute Petitioner's contentions regarding this limitation. *See* PO Resp. 6–31. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that Villar teaches or suggests limitation 1(d).

f. limitation 1(e): "determining whether rail seat abrasion is present along the rail road track"

Claim 1 recites "determining whether rail seat abrasion is present along the rail road track." Ex. 1001, 15:51–52. Because Villar does not explicitly discuss RSA, Petitioner relies on Choros for teaching or

suggesting limitation 1(e)—"determining whether rail seat abrasion is present along the rail road track." *Id.* at 37–45. According to Petitioner, "one of ordinary skill in the art would have understood that *Choros* discloses measuring RSA at each of the left rail/tie . . . and right rail/tie . . . seats." *Id.* at 38 (citing Ex. 1007 Fig. 8; Ex. 1004 ¶ 65). Petitioner adds that it would have been obvious "to implement *Villar's* automated railroad track inspection vision system with *Choros*'s method of measuring RSA (i.e., measuring a vertical distance between rail base and crosstie top surface heights) to automatically determine whether RSA is present along a railroad track." *Id.* at 39 (citing Ex. 1004 ¶ 66).

According to Petitioner, one of ordinary skill in the art would have implemented (1) "Villar's vision inspection system 30 to move along the railroad track, with the lasers 40 . . . projecting beams of light at the track bed and producing a projected line . . . following the top surface contours of the left rail/tie and right rail/tie seats, pursuant to Choros' method of measuring RSA requiring measurement of the vertical distance between rail base and crosstie *top surface heights*"; (2) "the cameras 50 . . . of Villar's system 30 to receive a portion of the light reflected from the contour of the surface of the railroad track components illuminated along the projected line L on the track bed and generate at least one image representative of the profile of the scanned portion of the railroad track." and (3) "Villar's processing device 60 to analyze whether RSA is present along the imaged portion of the railroad track by determining, in the generated contour image, the vertical distance between the imaged rail base and crosstie top surface heights." *Id.* at 39–41.

In addition, Petitioner cites Villar as teaching that "[e]valuating and comparing contour features of an image to determine potential defects through various image processing tools . . . was well-known and within the skill of one of ordinary skill in the art at the relevant time." *Id.* at 41 (quoting Ex. 1004 ¶ 70) (citing Ex. 1005 ¶¶ 43, 47, 52, 55). Petitioner explains that "Villar appreciates the need to identify and assess a variety of railway track components for defects by generating and comparing relevant contour orientations through various rail and tie contour line-fitting and orientation comparison algorithms." *Id.* at 41. In support of this assertion, Petitioner refers to Villar's embodiments including those shown in Figures 5, 7A, and 8. *Id.*at 41–43 (citing Ex. 1005, ¶¶ 43, 47, 50, 52).

Patent Owner argues that the combination of Villar and Choros do not teach or suggest limitation 1(e). PO Resp. 7–16. Petitioner relies on the testimony of Dr. Bovik that (1) "Villar does not disclose or suggest determining whether rail seat abrasion is present or measuring it," and (2) Choros does not disclose a processor that analyzes railroad track images to measure distances or determines rail seat abrasion. *Id.* at 8 (citing Ex. 2001, ¶ 50. These statements, however, are not relevant to Petitioner's contentions, because Petitioner relies on Choros, not Villar, for measuring and determining rail seat abrasion, and Petitioner relies on Villar, not Choros for a process that makes measurements and makes determinations. "[O]ne cannot show non-obviousness by attacking references individually where, as here, the rejections are based on combinations of references." *In re Keller*, 642 F.2d 413, 425 (CCPA 1981); *In re Merck & Co.*, 800 F.2d 1091, 1097 (Fed. Cir. 1986). Instead, the evidence of record supports Petitioner's

showing that the combination of Villar and Choros teaches or suggests determining whether rail seat abrasion is present along the rail road track.

Patent Owner also reiterates the arguments that a person of ordinary skill would not have combined a machine vision system with a manual measurement method and Villar teaches away from the manual method of Choros. PO Resp. 8–15. As explained above, in Section II.D.1, the evidence of record supports Petitioner's position that a person of ordinary skill in the art would have found it obvious to combine Villar's automated railroad track inspection vision system with Choros's method of measuring RSA.[12]

Accordingly, we determine that Petitioner has established by a preponderance of the evidence that Villar teaches or suggests limitation 1(e).

g. limitation 1(f): "wherein, when determining whether rail seat abrasion is present, the at least one processor compensates for a tilt of the rail road track"

Claim 1 recites "wherein, when determining whether rail seat abrasion is present, the at least one processor compensates for a tilt of the rail road track." Ex. 1001, 15:53–55. Petitioner asserts that the combination of Villar, Choros, Casagrande, and Szwilski discloses this limitation. Pet. 46–54. Because neither Villar nor Choros explicitly discusses compensating for a tilt of a railroad vehicle when determining whether RSA is present, Petitioner relies on Casagrande and Szwilski for teaching or suggesting

[12] Patent Owner argues that Petitioner's annotated figures of Choros Figure 8 are "fake prior art." PO Resp. 16 (citing Pet. 39–40, 43–44), 30 (citing Pet. 54). And Patent Owner argues that depositions from other IPRs that involve different patents is inapplicable to this case. Sur-Reply 11–12 (citing Ex. 1043; Ex. 1044). Because we do not rely on these annotated figures or exhibits for our conclusions, we do not address these arguments.

limitation 1(f)—"wherein, when determining whether rail seat abrasion is present, the at least one processor compensates for a tilt of the railroad track." *Id.* at 46–54. Petitioner contends that a person of ordinary skill in the art would understand that Casagrande's system "detects a vertical alignment error between each triangulation reading device caused by, e.g., a vertical deviation of the railway and/or tramway carriage." *Id.* at 48 (citing Ex. 1008 ¶ 36; Ex. 1004 ¶ 81). Moreover, Petitioner adds that it would have been obvious to add this feature with the combined Villar and Choros system for automated RSA railroad track inspection in order to compensate for the tilt of the system when going around a curve. *Id.* at 49 (citing Ex. 1004 ¶ 82). According to Petitioner, "[t]o the extent *Casagrande* does not explicitly disclose compensating an RSA measurement for vertical tilt error, *Casagrande* describes compensating imaged rail profile and other measured geometric parameters . . . for vertical alignment errors" and "Villar appreciates that '<u>other measurable aspects</u> of the railroad track can be determined or detected from the image data of the track bed.'" *Id.* at 49–50 (citing Ex. 1005 ¶¶ 8, 23, 43, 47, 50, 52, claims 1, 15, 23; Ex. 1004 ¶ 83).

Petitioner also relies on Szwilski as teaching or suggesting "accounting for vertical track inclination errors to accurately represent imaged railroad component position data when determining rail defects." *Id.* at 50. According to Petitioner,

> in light of Szwilski's teachings extending vertical tilt compensation corrections to 'other rail [] defects,' it would have been obvious and well within the skill of one of ordinary skill in the art to implement *Villar* and *Choros*' automated RSA railroad track inspection system to account for vertical track inclination errors to accurately represent the imaged railroad component position data.

Id. at 51–52 (alteration in original).

Petitioner asserts it would have been obvious to combine "Villar and Choros's automated RSA railroad track inspection system to determine the vertical tilt of the railroad track from the image representative of a profile of the scanned railroad track as taught by Casagrande" because Villar itself, "identifies and assesses numerous railway track components, including ties and rails for defects and servicing through the use of 'image processing tools known in the art for analyzing image data'" and recognizes that "other measurable aspects of the railroad track can be determined or detected from the image data of the track bed.'" *Id.* at 53 (citing Ex. 1005, ¶¶ 43, 47, 52, 55, Figs. 7–8; Ex. 1004, ¶ 90). Petitioner adds that "further to Casagrande and Szwilski's teachings, when determining whether RSA is present along the railroad track, Villar's system would compensate the RSA measurement for any vertical alignment error." *Id.* at 54 (citing Ex. 1004, ¶ 91).

Patent Owner argues that the combination of Villar, Choros, Casagrande, and Szwilski do not teach or suggest limitation 1(f). PO Resp. 17–31.

First, Patent owner asserts that Casagrande does not teach or suggest limitation 1(f). PO Resp. 17–23. Patent Owner asserts that "[a]lthough Casagrande discloses some rail related measurements that its system can make, it conspicuously fails to mention rail seat abrasion." *Id.* at 18 (citing Ex. 2001, ¶ 69; Ex. 1008, ¶¶ 7, 43). This argument is not relevant to Petitioner's contentions because Petitioner relies on Choros, not Casagrande, for measuring and determining rail seat abrasion. As mentioned above with respect to limitation 1(e), one cannot show non-obviousness by attacking

references individually where the rejections are based on combinations of references. *See Keller*, 642 F.2d at 425; *Merck*, 800 F.2d at 1097.

Further, Patent Owner contends that Casagrande "is in fact incapable of measuring rail seat abrasion" because it does not measure points on the crossties. *Id.* (citing Ex. 1008, Figs. 1–5, ¶¶ 22–30; Ex. 2001 ¶ 69). Patent Owner asserts Casagrande does not compensate for rail tilt but, instead, "adjust[s] only for measurement errors caused by 'oscillations' or 'elastic deformation' of the 'vehicle' or 'carriage' . . . on which the measurement units are mounted," but not the vertical displacement of one rail in regard to another rail. *Id.* at 20–21 (citing Ex. 1008, ¶¶ 36, 43; Ex. 2001, ¶ 71). According to Patent Owner, "[b]ecause [in Casagrande] the entire vehicle or carriage tilts, each measurement unit mounted on the vehicle or carriage will likewise tilt the same as the vehicle, which means that such a tilt will not disturb the alignment between the front, middle, and back measurement units as monitored by the laser bar 32 and sensors 16." *Id.* at 22 (citing Ex. 2001, ¶ 73).

In particular, Patent Owner premises this argument on a particular reading of Casagrande's language that "Fig. 6 shows schematically the principle of compensation for the errors due to elastic deformation of the railway or tramway carriage." Ex. 1008, ¶ 36. According to Patent Owner, the phrase "railway or tramway carriage" refers to a "railway carriage" or a "tramway carriage," and "railway" cannot be read to refer to railway tracks. Sur-Reply 14. Patent Owner points to later language stating that measurements are "insensitive to elastic deformation and oscillation of the railway carriage on which [the device] is mounted" as consistent with this interpretation. *Id.* (citing Ex. 1008, ¶ 43).

We do not agree with Patent Owner's reading of Casagrande. The context of Casagrande makes clear that it is an "Apparatus for Monitoring the Rails of a Railway or Tramway Line." Ex. 1008, code (54); *see also* Ex. 1008, code (57) ("A laser apparatus for monitoring *the rails* of a railway or tramway line, characterized by comprising at least two measurement units (4,8) mounted on a railway carriage and operating at least on the *inner part of the two rails* (6), along which said carriage is made to advance. . . .") (emphasis added), ¶ 40 (stating that the invention "enables the appropriate parameters of a *railway line* to be measured without any contact with the rails and without the need for any mechanical centering device"). Thus, it is clear that the phrase Patent Owner relies on refers to railway tracks, rather than a railway carriage.

In addition, we credit Dr. Papanikolopoulos's testimony explaining that "[i]t was well-known that a rail in the field may be slanted, tilted, canted, and/or banked at curves at some angle away from vertical either by design or due to the load of passing trains in some track portions" and "[i]t was also well-known at the relevant time to compensate for this tilt of a railroad track when determining a railroad track component defect." Ex. 1004, ¶ 78. This testimony is consistent with the objective evidence provided, including the evidence related to Federal Railroad Administration proceedings. *See* Ex. 1020; Ex. 1021; Ex. 1040; Ex. 1041. We also credit Dr. Papanikolopoulos's testimony that "one of ordinary skill in the art would understand that because Casagrande's apparatus measures any lack of alignment of 'the position in height of each triangulation reading device located in the two end measurement units 20 and 30,' the system detects a vertical alignment error between each triangulation reading device caused

by, e.g., a vertical deviation of the railway and/or tramway carriage." Ex. 1004, ¶ 81 (emphasis in original) (citing Ex. 1008, ¶ 36). This is consistent with Casagrande's disclosure, including Figure 6, which shows a measuring device on railway tracks, including "laser bar 32 emitted by a source 34 positioned in the central measurement unit 10 and received by a sensor 16 positioned in the measurement unit 20, 30 and able to constitute a precise alignment of the points of measurement." Ex. 1008, ¶ 36. Petitioner explains, and we agree, that "[n]othing in Casagrande suggests that railway deformation, including vertical deviation, must occur for each rail concurrently and at an angle causing tilt of an entire vehicle." Reply 15.

We give less weight to Dr. Bovik's testimony to the contrary that Casagrande adjusts only for measurement errors caused by oscillations of the vehicle, and does not measure tilt of the rails. Ex. 2001, ¶¶ 70–73. Dr. Bovik's testimony does not explain how this reading of Casagrande is consistent with the overall context of the reference or with Figure 6 itself, which shows a measurement device on railway tracks. *Id.* Nor does Dr. Bovik's testimony cite to any other objective evidence.

Second, Patent Owner asserts that Szwilski does not disclose limitation 1(f). PO Resp. 25. According to Patent Owner, "Szwilski's determination of track inclination is based on the positions of its GPS receivers and calculations based on those positions, rather than based on any image, or profile in an image, of a railroad track." *Id.* at 25–26 (citing Ex. 2001, ¶ 79). Moreover, Patent Owner asserts that "Szwilski's measurements are based on the location of the rail tops," but the claim requires determining abrasion based on the bottom of the rail ("rail seat"). *Id.* at 26 (citing Ex.

1001, 15:38–39, 50–55, 12:64–14:6, Fig. 17; Ex. 2001, ¶ 80), 31 (citing Ex. 2001, ¶ 88).

Petitioner responds that "the Petition does not rely upon or propose bodily incorporating Szwilski's specific systems and processes to determine RSA," but instead relies on Szwilski's "teachings regarding vertical tilt compensation corrections and extending those corrections to 'other rail [] defects,' would have suggested" to a person of ordinary skill in the art "to implement Villar and Choros' automated RSA railroad track inspection system to account for vertical track inclination errors to accurately represent the imaged railroad component position data when determining whether a well-known 'rail [] defect[],' such as RSA, is present." Reply 17 (citing Pet. 51–52; Ex. 1004, ¶ 87).

Patent Owner argues that a person of ordinary skill "would not have looked to or implemented Szwilski to compensate for railroad track tilt in determining rail seat abrasion because Szwilski's system is far too inaccurate." PO Resp. 27 (citing Ex. 2001 ¶ 81), 31 (citing Ex. 2001 ¶ 88). Petitioner responds that the "Petition is not relying on Szwilski to determine RSA, but instead for its imaged rail defect tilt compensation teachings." Reply 17–18. Patent Owner argues that "a useful system for determining RSA . . . must be able to measure vertical distance or depth at least every 20 inches," but Szwilski "determines its coordinates (vertical and horizontal) only about every 14.6 feet" and is therefore not precise enough to be useful for determining RSA. *Id.* at 28.

We agree with Petitioner that the Petition relies on the combined disclosures of Villar and Choros together to teach or suggest determining RSA, and Szwilski is relied upon solely for compensating for vertical tilt due

to rail defects. *See* Pet. 37–54; Reply 16–18. Indeed, we agree with Petitioner, in Section II.D.2.f, that a preponderance of the evidence shows the combined disclosures of Villar and Choros teach or suggest limitation 1(e) ("determining whether rail seat abrasion is present along the rail road track"). We also credit Dr. Papanikolopoulos's testimony that "Szwilski's system determines the presence of any vertical 310 tilt error . . . relative to horizontal . . . and corrects position coordinate data of the imaged component to account for the tilt," including rail displacement and other rail defects. Ex. 1004, ¶ 86 (citing Ex. 1009, 20, Figs. 3, 5). Similarly, we credit Dr. Papanikolopoulos's testimony that "it would have been obvious and well within the skill of one of ordinary skill in the art . . . to implement Villar and Choros' automated RSA railroad track inspection system to account for vertical track inclination errors to accurately represent the imaged railroad component position data when determining whether a well-known 'rail [] defect[],' such as RSA, is present on the railroad track." *Id.* ¶ 87.

Third, Patent Owner argues that Petitioner does not sufficiently show a person of ordinary skill in the art would have combined Szwilski with Villar and Choros. PO Resp. 25. According to Patent Owner, Petitioner's expert provides only an unsubstantiated statement that "'it would have been obvious' to apply [Szwilski's] correction mechanism to 'RSA' because '[t]he combination would have yielded the claimed subject matter.'" *Id.* (citing Ex. 1004, ¶ 87).

We do not agree with Patent Owner's characterization of the record. The quoted testimony, paragraph 87, follows several paragraphs in which Dr. Papanikolopoulos's discusses the teachings of Szwilski (Ex. 1004, ¶¶ 84–86) and then states that in light of those teachings it would have been

obvious "to implement Villar and Choros' automated RSA railroad track inspection system *to account for vertical track inclination errors to accurately represent the imaged railroad component position data* when determining whether a well-known 'rail[] defect[],' such as RSA, is present on the railroad track." *Id.* ¶ 87. After this statement, Dr. Papanikolopoulos adds that "[t]he combination would have yielded the claimed subject matter." *Id.* Patent Owner's characterization of this paragraph of the record ignores much of the expert's reasoning, and unfairly characterizes the substance as simply relying on the claimed invention for the reason a person of ordinary skill in the art would combine the references. In doing so, Patent Owner does not address Dr. Papanikolopoulos's opinion, which, as discussed above, we find credible, that a person of ordinary skill in the art would have been motivated to combine Szwilski's teachings of compensating for vertical tilt to the measuring system of Villar/Choros because it would lead to more accurate representation of the measured data. We, therefore, agree with Petitioner that the record shows, by a preponderance of the evidence, that a person of ordinary skill in the art would have been motivated to combine the teachings of Szwilski with those of Villar and Choros.

Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combined teachings of Villar, Choros, Casagrande, and Szwilski teaches or suggests limitation 1(f).

h. Conclusion

After reviewing the evidence of record, we are persuaded that Petitioner demonstrates that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests claim 1's preamble and limitations.

Moreover, we are persuaded that Petitioner provides a reasonable rationale for combining the four references. Thus, we determine that Petitioner establishes by a preponderance of the evidence that claim 1 would have been obvious to one of ordinary skill in the art in view of the combination of Villar, Choros, Casagrande, and Szwilski.

3. *Dependent Claim 2*

Dependent claim 2 depends from claim 1 and recites:

> 2. [a] A system as defined in claim 1, wherein the processor compensates for a tilt of the rail road track, by the steps comprising:
>
> [b] determining a height of a left rail base, right rail base, left crosstie and right crosstie;
>
> [c] determining a tilt correction factor;
>
> [d] determining an actual delta for the right and left rail bases; and
>
> [e] determining a rail seat abrasion value for the right and left rail bases.

Ex. 1001, 15:56–65 (bracketing added consistent with Petitioner's analysis of the claim limitation; *see* Pet. 54–56).

a. limitation 2(a): "wherein the processor compensates for the tilt of the rail road track"

Claim 2 recites "wherein the processor compensates for a tilt of the rail road track." Ex. 1001, 15:56–58. Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claim 1's limitation (f). Pet. 54.

Patent Owner relies on its position with respect to claim 1 and does not provide additional argument challenging Petitioner's contention as to claim 2(a). PO Resp. 32.

For the reasons articulated above, in Section II.D.2.f, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests the subject matter of the claim 2(a) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

b. limitation 2(b): "determining a height of a left rail base, right rail base, left crosstie and right crosstie"

Claim 2 recites "determining a height of a left rail base, right rail base, left crosstie and right crosstie." Ex. 1001, 15:59–60. Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 1's limitation (e). Pet. 54–55.

Patent Owner relies on its position with respect to claim 1 and does not provide additional argument challenging Petitioner's contention as to claim 2(b). PO Resp. 32.

For the reasons articulated above, in Section II.D.2.e, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar and Choros teaches or suggests the subject matter of the claim 2(b) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

c. limitation 2(c): "determining a tilt correction factor"

Claim 2 recites "determining a tilt correction factor." Ex. 1001, 15:61. Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claim 1's limitation (f). Pet. 55. In addition, Petitioner adds that "[o]ne of

ordinary skill in the art would have thus understood that the value used to compensate the RSA measurement for any vertical alignment or tilt error would constitute the claimed 'tilt correction factor.'" *Id.* (citing Ex. 1004, ¶ 95).

Patent Owner argues that "[n]one of the references disclose or suggest the use of any 'tilt correction factor.'" PO Resp. 32 (citing Ex. 2001 ¶ 91).

The record evidence support Petitioner's position on tilt correction factor. We credit Dr. Papanikolopoulos's testimony explaining that "[i]n my opinion, one of ordinary skill in the art would have thus understood that the value used to compensate the RSA measurement for any vertical alignment or tilt error would constitute the claimed 'tilt correction factor.'" Ex. 1004, ¶ 95. This testimony is consistent with the analysis provided for limitation claim 1(f), discussed above, in Section II.D.2.f., which we find credible.

We give less weight to Dr. Bovik's opinion, which simply concludes that none of the references use the exact term "tilt correction factor." Ex. 2001, ¶ 91. However, there is no *ipsissimis verbis* test for determining whether a reference discloses a claim element, i.e., identity of terminology is not required. *In re Bond*, 910 F.2d 831, 832 (Fed. Cir. 1990). Dr. Bovik does not address Dr. Papanikolopoulos's testimony regarding what one of ordinary skill in the art would understand from the teachings of the references.

Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combined teachings of Villar, Choros, Casagrande, and Szwilski teaches or suggests limitation 2(c).

d. limitation 2(d): "determining an actual delta for the right and left rail bases"

Claim 2 recites "determining an actual delta for the right and left rail bases." Ex. 1001, 15:62–63. Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 1's limitation (e). Pet. 55–56. In addition, Petitioner adds that "[b]ecause Villar and Choros' RSA railroad inspection vision system determines the distance or difference between the left rail base and crosstie heights, and the right rail base and crosstie heights, Villar's system determines an 'actual delta' for the right and left rail bases." *Id.* (citing Ex. 1004, ¶ 97).

Patent Owner argues that "[n]one of the references disclose or suggest the use of . . . an 'actual delta' for the rail bases." PO Resp. 32 (citing Ex. 2001 ¶ 91).

The record evidence supports Petitioner's position on actual delta. We credit Dr. Papanikolopoulos's testimony explaining that "[b]ecause Villar and Choros' RSA railroad inspection vision system determines the distance or difference between the left rail base and crosstie heights, and the right rail base and crosstie heights, Villar's system determines an 'actual delta' for the right and left rail bases." Ex. 1004, ¶ 97. This testimony is consistent with the analysis provided for limitation claim 1(e), discussed above, in Section II.D.2.e., which we find credible.

We give less weight to Dr. Bovik's opinion, which simply concludes that none of the references use the exact term "actual delta." Ex. 2001, ¶ 91. Dr. Bovik does not address Dr.

Papanikolopoulos's testimony regarding what one of ordinary skill in the art would understand from the teachings of the references. *Id.*

Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combination of Villar and Choros teaches or suggests limitation 2(d).

e. limitation 2(e): "determining a rail seat abrasion value for the right and left rail bases"

Claim 2 recites "determining a rail seat abrasion value for the right and left rail bases." Ex. 1001, 15:64–65. Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claim 1's limitations (e) and (f) and claim 2's limitations (b) and (c). Pet. 56 (citing Ex. 1004, ¶ 99).

Patent Owner relies on its position with respect to claim 1 and does not provide additional argument challenging Petitioner's contention as to claim 2(b). PO Resp. 32.

For the reasons articulated above, in Sections II.D.2.e–f and II.D.3.b–c, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests the subject matter of the claim 2(e) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

4. *Dependent Claim 5*

Claim 5 depends from claim 2 and recites "wherein the step of determining the actual delta is accomplished based upon the tilt correction factor." Ex. 1001, 16:10–12.

Petitioner asserts that "Szwilski discloses using 'simple trigonometry' to make track inclination and real-time 'x' and 'y' coordinate corrections to reflect the accurate position of the rail 120 being surveyed." Pet. 57 (citing Ex. 1009, 12–14, 16–20, Fig. 9). According to Petitioner, "it would have been obvious to one of ordinary skill in the art to correct the position coordinates of the components in the contour image by implementing 'x' and 'y' coordinate corrections to each rail, thus correcting the imaged railroad track component position data," which would "ensure accurate height measurements where the rail is tilted." *Id.* at 57–58 (citing Ex. 1004, ¶¶ 101–102).

Patent Owner relies on its position with respect to claims 1 and 2 and does not provide additional argument challenging Petitioner's contention as to claim 5. PO Resp. 33.

We credit Dr. Papanikolopoulos's unrebutted testimony on this issue. Ex. 1004, ¶¶ 101–103. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combined teachings of Villar, Choros, Casagrande, and Szwilski render obvious claim 5.

5. *Dependent Claim 6*

Claim 6 depends from claim 2 and recites "wherein the step of determining the rail seat abrasion value is accomplished based upon the actual delta." Ex. 1001, 16:13–15. Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 1(e). Pet. 58.

Patent Owner relies on its position with respect to claims 1 and 2 and does not provide additional argument challenging Petitioner's contention as to claim 5. PO Resp. 33.

We credit Dr. Papanikolopoulos's unrebutted testimony on this issue. Ex. 1004, ¶ 104. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combined teachings of Villar, Choros, Casagrande, and Szwilski render obvious claim 6.

6. *Independent Claim 7*

Independent claim 7 is a method claim that recites:

> 7. [preamble] A method for determining rail seat abrasion of a rail road track, the method comprising the steps of:
>
> (a) determining a height of a left rail base, right rail base, left crosstie and right crosstie;
>
> (b) recording the heights of the left rail base, right rail base, left crosstie and right crosstie;
>
> (c) determining a tilt correction factor;
>
> (d) determining an actual delta for the right and left rail bases; and
>
> (e) determining a rail seat abrasion value for the right and left rail bases.

Ex. 1001, 16:16–26 (bracketing added consistent with Petitioner's analysis of the claim limitation "[preamble]"; *see* Pet. 59).

f. limitation 7(preamble): "a method for determining rail seat abrasion of a rail road track"

The preamble of claim 7 recites "a method for determining rail seat abrasion of a rail road track." Ex. 1001, 16:16–17. The preamble of claim 7 differs from the preamble of claim 1 only in that it recites a method as opposed to a system. *Compare* Ex. 1001, 15:38–39 *with id.* at 16:16–17. Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 1's preamble. Pet. 59–60.

Patent Owner relies on its position with respect to claim 1 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Section II.D.2.a, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar and Choros teaches or suggests the subject matter of the preamble of claim 7 and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

a. limitation 7(a): "determining a height of a left rail base, right rail base, left crosstie and right crosstie"

Claim 7 recites "determining a height of a left rail base, right rail base, left crosstie and right crosstie." Ex. 1001, 16:18–19. For claim 7's limitation (a), Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 2(b). Pet. 59–60.

Patent Owner relies on its position with respect to claim 2 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Section II.D.3.b, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar an Choros teaches or suggests the subject matter of limitation 7(a) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

b. limitation 7(b): "recording the heights of the left rail base, right rail base, left crosstie and right crosstie"

Claim 7 recites "recording the heights of the left rail base, right rail base, left crosstie and right crosstie." Ex. 1001, 16:20–21. For claim 7's limitation (b), Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 1's limitation (e) and claim 2's limitation b. Pet. 59–60.

Patent Owner relies on its position with respect to claims 1 and 2 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Sections II.D.2.e and II.D.3.b, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar and Choros teaches or suggests the subject matter of limitation 7(b) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

c. limitation 7(c): "determining a tilt correction factor"

Claim 7 recites "determining a tilt correction factor." Ex. 1001, 16:22. For claim 7's limitation (c), Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 2(c). Pet. 59–60.

Patent Owner relies on its position with respect to claim 2 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Section II.D.3.c, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar and Choros teaches or suggests the subject matter of

limitation 7(c) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

d. limitation 7(d): "determining an actual delta for the right and left rail bases"

Claim 7 recites "determining an actual delta for the right and left rail bases." Ex. 1001, 16:23–24. For claim 7's limitation (d), Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 2(d). Pet. 59–60.

Patent Owner relies on its position with respect to claim 2 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Section II.D.3.d, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar and Choros teaches or suggests the subject matter of limitation 7(d) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

e. limitation 7(e): "determining a rail seat abrasion value for the right and left rail bases"

Claim 7 recites "determining a rail seat abrasion value for the right and left rail bases." Ex. 1001, 16:25–26. For claim 7's limitation (e), Petitioner relies on the combined teachings of Villar and Choros in the same manner as for claim 2(e). Pet. 59–60.

Patent Owner relies on its position with respect to claim 2 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Section II.D.3.e, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar and Choros teaches or suggests the subject matter of limitation 7(e) and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

7. *Dependent Claim 10*

Claim 10 depends from claim 7 and recites "wherein step (d) is accomplished based upon the tilt correction factor." Ex. 1001, 16:37–38. Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claim 5. Pet. 60.

Patent Owner relies on its position with respect to claim 7 and does not provide additional argument challenging Petitioner's contention as to claim 10. PO Resp. 34.

We credit Dr. Papanikolopoulos's unrebutted testimony on this issue. Ex. 1004, ¶ 108. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combined teachings of Villar, Choros, Casagrande, and Szwilski render obvious claim 10.

8. *Dependent Claim 11*

Claim 11 depends from claim 7 and recites "wherein step (e) is accomplished based upon the actual delta for the right and left rail bases." Ex. 1001, 16:39–41. Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claims 1 and 5. Pet. 61.

Patent Owner relies on its position with respect to claim 7 and does not provide additional argument challenging Petitioner's contention as to claim 11. PO Resp. 34.

We credit Dr. Papanikolopoulos's unrebutted testimony on this issue. Ex. 1004, ¶ 109. Accordingly, we determine that Petitioner has established by a preponderance of the evidence that the combined teachings of Villar, Choros, Casagrande, and Szwilski render obvious claim 11.

9. *Independent Claim 12*

Independent claim 12 is a method claim that recites:

> 12. [preamble] A method for determining rail seat abrasion of a rail road track, the method comprising the steps of:
>
> (a) moving an inspection system along the track;
>
> (b) receiving image data corresponding to at least a portion of the track;
>
> (c) determining a measurement of the rail seat abrasion for the portion of the track, wherein the measurement are [sic] adjusted for tilt encountered as the inspection system moves along the track; and
>
> (d) determining whether rail seat abrasion exists based upon the adjusted measurement.

Ex. 1001, 16:42–52 (bracketing added consistent with Petitioner's analysis of the claim limitation "[preamble]"; *see* Pet. 61).

The majority of the limitations of claim 12 are substantively similar to those recited by claims 1 and 7. In particular, the preamble of claim 12 is identical to that in claim 7. *Compare* Ex. 1001, 15:38–39 *with id.* at 16:42–43. Claim 12's limitation (b) is similar to claim 1's limitation (b), which recites "generating at least one image representative of a profile of at least a portion of the rail road track." *Compare* Ex. 1001, 15:43–47 *with id.* at

16:45–46; *see also* Pet. 61–62. Claim 12's limitations (c) and (d) are similar to the combination of claim 1's limitations (e) and (f), which recite "determining whether rail seat abrasion is present," wherein tilt of the rail is compensated for. *Compare* Ex. 1001, 15:51–55 *with id.* at 16:47–52; *see also* Pet. 62. In addition, Petitioner relies on Villar as teaching or suggesting the subject matter recited by claim 12's limitation (a). Pet. 61 (citing Ex. 1005 ¶¶ 26, 28).

Patent Owner relies on its position with respect to claim 1 and does not provide additional argument challenging Petitioner's contention as to claim 7. PO Resp. 21–22.

For the reasons articulated above, in Section II.D.3.a, c, e–f, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests the subject matter of claim 12's limitations preamble and limitations (b)–(d). In addition, we agree that Villar's disclosure that inspection system 30 is assembled onto a rigid framework 32 that can be mounted on an inspection vehicle teaches or suggests claim 12's limitation (a) "moving an inspection system along the track." *See* Pet. 61; Ex. 1005, ¶¶ 26, 28, claim 1.

We, therefore, find a preponderance of the evidence supports Petitioner's position that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests the subject matter of claim 12 and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

10. *Dependent Claim 13*

Dependent claim 13 recites:

> 13. A method as defined in claim 12, wherein step (c) further comprises the steps of:
>
> [a] determining a height of a left rail base, right rail base, left crosstie and right crosstie;
>
> [b] determining a tilt correction factor;
>
> [c] determining an actual delta for the right and left rail bases; and
>
> [d] determining a rail seat abrasion value.

Ex. 1001, 16:53–60 (bracketing added).

The majority of the limitations of claim 13 are substantively similar to those recited by claims 1 and 2. In particular, the claim 13(a) is identical to claim 2(b), claim 13(b) is identical to claim 2(c), claim 13(c) is identical to claim 2(d), and claim 13(d) is similar to claim 2(e). *Compare* Ex. 1001, 15:56–65 *with id.* at 16:53–60.

Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claims 1 and 2. Pet. 62–63.

Patent Owner relies on its position with respect to claims 1 and 2 and does not provide additional argument challenging Petitioner's contention as to claim 13. PO Resp. 35.

We credit Dr. Papanikolopoulos's unrebutted testimony on this issue. Ex. 1004, ¶ 116. For the reasons articulated above, in Sections II.D.2, and II.D.3, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests the subject matter of claim 13 and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

11. *Dependent Claim 17*

Claim 17 depends from claim 13 and recites "wherein the step of determining the rail seat abrasion value is accomplished based upon the actual delta." Ex. 1001, 18:1–3. Petitioner relies on the combined teachings of Villar, Choros, Casagrande, and Szwilski in the same manner as for claim 6. Pet. 63.

Patent Owner relies on its position with respect to claims 1 and 2 and does not provide additional argument challenging Petitioner's contention as to claim 17. PO Resp. 35.

We credit Dr. Papanikolopoulos's unrebutted testimony on this issue. Ex. 1004, ¶ 118. For the reasons articulated above, in Sections II.D.2, and II.D.3, we find a preponderance of the evidence supports Petitioner's position that the combination of Villar, Choros, Casagrande, and Szwilski teaches or suggests the subject matter of claim 17 and a sufficient rationale for combining the teachings of the references with a reasonable expectation of success in arriving at the claimed subject matter has been articulated.

12. *Dependent Claims 3, 8, and 14*

Petitioner contends that claims 3, 8, and 14 of the '320 patent are unpatentable because their subject matter would have been obvious over the combined disclosures of Villar, Choros, Casagrande, Szwilski, and Khattak. Pet. 64–73.

a. Overview of Khattak

Khattak is titled "Pavement Distress Survey System." Ex. 1010, code (54). It describes a pavement inspection apparatus that determines the size and shapes of surface distress features in pavement, such as potholes, using video and infrared cameras. *Id.* at code (57). Khattak discloses that its

video camera "produces a first set of frames of raw electrical video pixel signals or data, concerning . . . the magnitude of the light radiation reflected by the pavement and received by the camera in an X-Y array (multiple pixel line)." *Id.* at 5:21–26. Khattak also discloses a "pixel reference means for determining the pixel to surface distance relationship, ratio, or correlation on a real time basis and to adjust or calibrate the raw pixel accordingly" by "count[ing] or measure[ing] the number of pixels within a video frame between two mixed or defined reference points and determin[ing] if the number varies between frames to maintain a real time correlation of the surface to pixel relationship." *Id.* at 6:32–45.

b. Analysis

Claims 3, 8, and 14 depend from claims 2, 7, and 13 and recite "determining vertical pixel counts for each of the heights of the left rail base, right rail base, left crosstie and right crosstie" and "normalizing the vertical pixel counts based upon a measurement index." Ex. 1001, 16:1–5, 16:29–33, 16:62–67.

Petitioner contends that one of ordinary skill in the art would understand that Villar's disclosure of "assess[ing] [railroad track] components for defects via contour line-fitting and orientation comparison algorithms" is done through "determining and comparing the vertical pixel counts of the imaged contoured railroad track components." Pet. 65 (citing Ex. 1005 Fig. 7A, ¶¶ 47, 50, 52; Ex. 1004 ¶ 121). Petitioner also contends that "it would have been obvious to one of ordinary skill in the art to implement Villar's system . . . by determining and comparing vertical pixel counts in the image for the left and right rail base heights . . . and left and right crosstie heights" because it would "provide another track component

defect for Villar's vision system to automatically identify and correct in furtherance of increasing railroad safety." *Id.* at 66–67 (citing Ex. 1007 Fig. 8; Ex. 1004 ¶ 123).

Petitioner points to Khattak's disclosure of "converting (or normalizing) the pixel counts based upon a measurement index, providing a surface distance to pixel correlation in terms of inches/pixel[s]" and "dynamically determining the pixel to surface distance relationship, ratio, or correlation on a real time basis" and adjusting or calibrating "the raw pixel accordingly to provide a much more accurate and dynamic (real time) determination of the surface distance to pixel correlation." Pet. 68–70 (citing Ex. 1010 Fig. 4, 5:21–26, 5:48–67, 6:31–58).

Finally, Petitioner explains that "[i]t would have been obvious to one of ordinary skill in the art to implement the automated RSA railroad track inspection vision system to convert (or normalize) pixel counts based upon a measurement index, as taught by *Khattak*" in order "to provide useful real-world information regarding the shape, size, contours, and position of imaged components relative to each other." Pet. 71 (citing Ex. 1010, 14:44–62; Ex. 1004 ¶ 130).

Patent Owner argues that "Villar does not disclose determining the vertical pixel counts for determining any height measurement," but instead only discloses pixel "averaging or summing the value of pixels in an entire region of interest to determine the presence of a crosstie." PO Resp. 36 (citing Ex. 1005, ¶ 46; Ex. 2001, ¶ 110). Patent Owner notes that the portion of Villar relied upon by Petitioner does not use the term "pixel" or disclose using pixel counts for determining height measurements, but instead discusses "using best fit or curve fitting techniques, edge detecting

techniques, and line fitting techniques to determine the distances or heights involved." *Id.* at 36–37 (citing Ex. 1005, ¶¶ 47, 50, 52, 55; Ex. 2001, ¶ 111).

In response, Petitioner asserts that Villar discloses that each image generated includes pixels "'given X-Y coordinates,'" showing the height contour of the imaged components along the track" and "[t]o identify track components, Villar analyzes the images for pixels indicating presence of a railroad track component." Reply 20 (citing Pet. 22, 35, 46, 49, 64–65; Ex. 1005, ¶¶ 24, 25, 27, 31, 32, 35; Ex. 1004, ¶ 119). According to Petitioner, Villar also discloses "assess[ing] the imaged components for potential defects through, e.g., contour line-fitting and orientation comparison algorithms, including for certain defects, comparing height contours of the imaged components." *Id.* (citing Pet. 40–44, 65–66; Ex. 1005, ¶¶ 43, 37, 50, 52, 53, 55, Figs. 7A, 8; Ex. 1004, ¶¶ 69–74, 119–122). As an example, Petitioner points to Figure 7A of Villar as showing "identifying rail wear by determining a 'measurable distance,' LD . . . between level L . . . and reference level L2 . . . –levels representing the respective height contours of the imaged pixel coordinates of the rail and tie plate in frame F1." *Id.* at 21 (citing Ex. 1005, Fig. 7A, ¶ 50). Similarly, Petitioner points to Figure 8 of Villar as disclosing a height measurement. *Id.* at 21–22 (citing Ex. 1005, Fig. 8, ¶ 53). Petitioner relies on testimony from Dr. Papanikolopoulos that a person of ordinary skill in the art would have understood that "these disclosures of Villar [] determining the measurable distance, LD, and height, Hb, and other 'measurable aspects' between the height contours of imaged railroad track components 'from the image data' would have included the step of determining vertical pixel counts." *Id.* at 22 (citing Ex. 1004, ¶¶ 69–74, 119–122).

Patent Owner argues that Dr. Papanikolopoulos's testimony is unsupported because it "cites only Villar, but points to no disclosure of 'determining vertical pixel counts.'" Sur-Reply 22 (citing Ex. 1004, ¶¶ 119–123).

We have reviewed the evidence and find that it weighs in favor of Petitioner's position. We credit Dr. Papanikolopoulos's testimony that the examples illustrated by Figure 7A and 8 of Villar disclose determining "the distance [or height] in pixels" of various measurements. Ex. 1004, ¶¶ 71–72, 121–122 (citing Ex. 1005, Fig. 7A, 8, ¶¶ 47, 50, 52). Dr. Papanikolopoulos provides annotated versions of Figures 7A and 8, reproduced below, to demonstrate the calculations he is referring to.

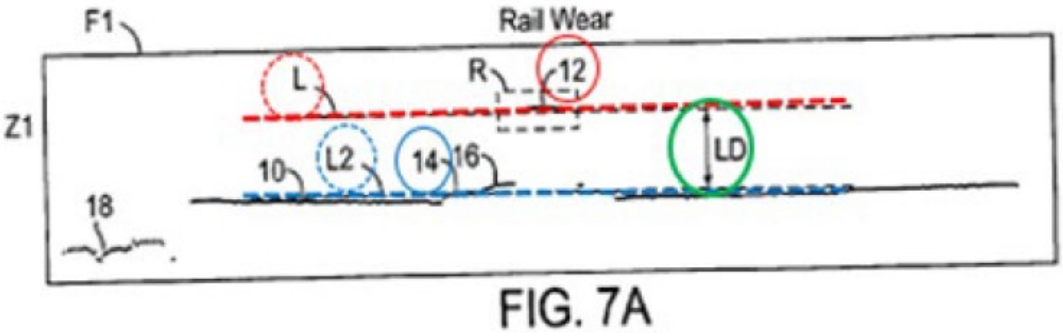
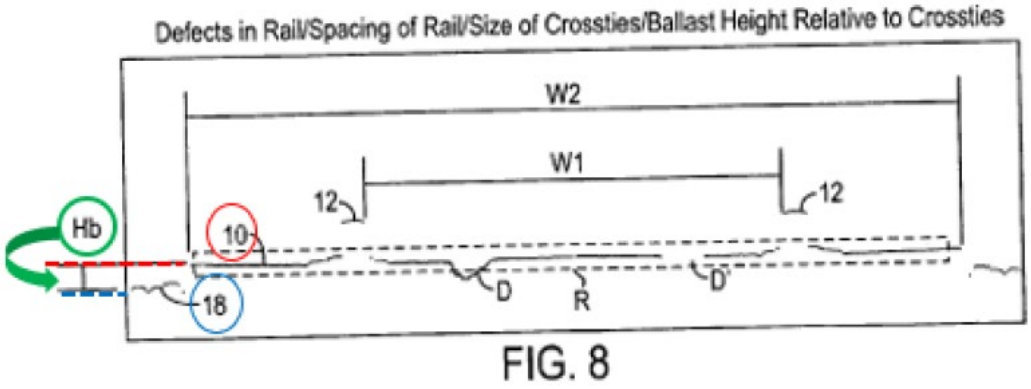


FIG. 7A

Villar, FIG. 7A (annotated).



Villar, FIG. 8 (annotated).

Ex. 1004, ¶¶ 71–72, 121–122. Figures 7A and 8 of Villar show "example frames of railroad track obtained with the disclosed inspection system." Ex. 1005, ¶¶ 17–18. The "wear of the rails can be determined from the image data" in Figure 7A "by determining whether the distance between the contour of the rail 12 and a reference point in a frame is less than the same distance in a prior frame." *Id.* ¶ 50. Similarly, "the height of ballast 18 relative to the crosstie 10" in Figure 8 can be determined by estimating the height Hb. *Id.* ¶ 53. Dr. Papanikolopoulos explains that "[s]uch algorithms would necessarily include determining vertical pixel counts for each rail base and crosstie top surface heights." Ex. 1004, ¶ 119. Dr. Papanikolopoulos concludes:

> Accordingly, it would have been obvious to one of ordinary skill in the art, in my opinion, to implement Villar's system to identify and assess the rail base and crosstie top surface height contours via contour line-fitting and orientation comparison algorithms by determining the left and right rail base and crosstie heights by determining and comparing vertical pixel counts in the image for the left and right rail base heights (blue dashed lines) and left and right crosstie heights (red dashed lines), as shown below in annotated FIG. 8. Implementing *Villar*'s system in this way

> would simply provide another track component defect for *Villar*'s vision system to automatically identify and correct in furtherance of increasing railroad safety.

Ex. 1004, ¶ 123. Dr. Papanikolopoulos's testimony that it was well known to determine a height measurement between objects in an image is consistent with the disclosure of Khattak. *See* Ex. 1010, 10:45–48, 10:57–11:16, 13:54–14:43 (determining width and length of features in an image using pixel values).[13]

Dr. Bovik, on the other hand does not address Villar's disclosure of the examples illustrated in Figures 7A and 8. *See* Ex. 2001, ¶¶ 108–112. Instead, Dr. Bovik focuses on the fact that certain paragraphs of Villar do not use the word "pixel" and that Villar does not explicitly disclose determining vertical pixel counts to determine a height. *Id.* ¶¶ 111–112. Dr. Bovik, however, does not address Dr. Papanikolopoulos's testimony on what the person of ordinary skill in the art would understand based on the disclosure of Villar, which is pertinent to the obviousness question at issue.

Accordingly, after reviewing the evidence of record, we are persuaded that Petitioner demonstrates that the combination of Villar,

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[13] Patent Owner argues that because Petitioner cites to these portions of Khattak for the first time in the Reply, we should disregard the evidence. Sur-Reply 23. However, we understand Petitioner to be relying on Khattak here to support testimony disputed by Patent Owner. This is a legitimate response to Patent Owner's arguments. We do not understand Petitioner to be changing its contentions such that it no longer relies on Villar as disclosing determining vertical pixel counts. Thus, we do not agree with Patent Owner that we should disregard these portions of Khattak. A party also may submit rebuttal evidence in support of its reply. *See Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1077–78 (Fed. Cir. 2015).

Choros, Casagrande, Szwilski, and Khattak teaches or suggests the limitations of claims 3, 8, and 14. Moreover, we are persuaded that Petitioner provides a reasonable rationale for combining the five references. Thus, we determine that Petitioner establishes by a preponderance of the evidence that claims 3, 8, and 14 would have been obvious to one of ordinary skill in the art in view of the combination of Villar, Choros, Casagrande, Szwilski, and Khattak.

13. *Dependent Claims 4, 9, and 15*

Petitioner contends that claims 4, 9, and 15 of the '320 patent are unpatentable because their subject matter would have been obvious over the combined disclosures of Villar, Choros, Casagrande, Szwilski, and Andersson. Pet. 73–76.

a. Overview of Andersson

Andersson is titled "Storage of Track Data in a Position-Controlled Tilt System." Ex. 1011, code (54). It describes a method and device "for tilting a car body of a vehicle in a trackbound train when the train passes through a track curve." *Id.* at code (57). Andersson discloses calculating and storing the current curve geometry the first time a train passes over a certain route. *Id.* at 5:16–19. On subsequent passes of that same route, Andersson discloses that the previously stored curve geometry is used to calculate "correct reference values for tilting of the car body for curves within the track section." *Id.* at 5:66–6:4. Moreover, Andersson states that "[t]o reduce the dependence on accidental occurrences during an individual running, the mean value of the two or three immediately preceding stored reference-value profiles may alternatively be used." *Id.* at 6:12–19.

b. Analysis

Claims 4, 9, and 15 depend from claims 2, 7, and 13 and recite "the tilt correction factor is accomplished based upon the left and right rail base heights and a standard tilt correction factor." Ex. 1001, 16:7–9, 16:34–36, 17:2–4.

Petitioner points to Andersson as disclosing "that the first time a train travels over a curved section of a track, the control system measures the geometry of the curve and stores the curve geometry in the memory of the control system." Pet. 74 (citing Ex. 1011, 5:16–19). "The next time the train travels over a certain track section, the previously measured and stored curve geometry is used to calculate 'correct reference values for tilting of the car body for curves within the track section'" using "the mean value of the two or three immediately preceding stored reference-value profiles may alternatively be used." *Id.* at 74–75 (citing Ex. 1011, 5:66–6:4, 6:12–18). According to Petitioner, it would have been obvious to one of ordinary skill in the art to use the "standard tilt correction factor, as taught by *Andersson*, to pre-emptively compensate imaged measurements for known vertical alignment tilt errors associated with an upcoming track geometry" to allow for "faster image processing of the data and thus, faster identification of potential RSA issues." *Id.* at 75 (citing Ex. 1004 ¶ 136).

Patent Owner argues that Andersson does not disclose the "standard tilt correction factor" as properly construed. PO Resp. 38–43. According to Patent Owner, "Andersson discloses a database of individual tilt corrections, one for each curve, along a section of track rather than a standard tilt correction factor that is applied to every curve." *Id.* at 41 (quoting Ex. 2001, ¶ 122). As discussed above, in Section II.B.2, we do not adopt Patent

Owner's narrow construction of the term "standard tilt correction factor." Moreover, we see nothing in the record that would exclude from a "standard tilt correction factor" Andersson's "reference values for tilting of the car body for curves." *See* Ex. 1011, 5:66–6:19; *see also* Ex. 1004 ¶¶ 135–136.

Patent Owner also argues that a person of ordinary skill in the art "would not look to Andersson to further modify the combination alleged by Petitioner of Villar, Choros, Casagrande, and Szwilski." PO Resp. 42 (quoting Ex. 2001, ¶ 125). According to Patent Owner, "the systems used in Casagrande and/or Szwilski measure and/or use as compensation for tilt as well" and the "additional use of the compensation employed by Andersson would thus act to overcompensate for all these other overlapping factors that cause any tilting in the railway." *Id.* at 43 (quoting Ex. 2001, ¶ 125).

The evidence of record supports Petitioner's position that a person of ordinary skill in the art would have found it obvious to combine the automated railroad track inspection vision system of Villar, Choros, Casagrande, and Szwilski with Andersson's method of pre-emptively compensating imaged measurements for known vertical alignment tilt errors associated with an upcoming track geometry. We credit the testimony of Dr. Papanikolopoulos that such method would not overcompensate for tilt, but would "allow for faster image processing of the data and thus, faster identification of potential RSA issues" leading to enhanced operational safety. Ex. 1004, ¶ 136. This testimony is consistent with the disclosure of Andersson, which describes its process as "eliminate[ing] the delay in the reference value signal which forms the basis of, and is used in, the control system which controls the tilting of a car body in a vehicle included in a train where the train travels through a track curve." Ex. 1011, 3:45–49.

We do not give as much weight to the testimony of Dr. Bovik, who relies on an overly narrow interpretation of the term "standard tilt correction factor." Ex. 2001, ¶ 122 ("Andersson does not disclose a stand tilt correction factor, let alone one distinct from a tilt correction factor."). And Dr. Bovik does not further explain, or point to objective evidence, for his conclusory statement that "[t]he additional use of the compensation employed by Andersson would thus act to overcompensate for all these other overlapping factors that cause any tilting in the railway, such as those caused by uneven heights of the rails, rail seat abrasion, or other physical conditions in the railway." *Id.* ¶ 125.

Accordingly, after reviewing the evidence of record, we are persuaded that Petitioner demonstrates that the combination of Villar, Choros, Casagrande, Szwilski, and Andersson teaches or suggests the limitations of claims 4, 9, and 15. Moreover, we are persuaded that Petitioner provides a reasonable rationale for combining the five references. Thus, we determine that Petitioner establishes by a preponderance of the evidence that claims 4, 9, and 15 would have been obvious to one of ordinary skill in the art in view of the combination of Villar, Choros, Casagrande, Szwilski, and Andersson.

IV. CONCLUSION[14]

For the foregoing reasons, Petitioner has proven by a preponderance of the evidence that the challenged claims of the '320 patent are unpatentable, as summarized in the following table:

[14] Should Patent Owner wish to pursue amendment of the challenged claims in a reissue or reexamination proceeding subsequent to the issuance of this

Claims	35 U.S.C. §	Reference(s)/ Basis	Claims Shown Unpatentable	Claims Not Shown Unpatentable
1, 2, 5–7, 10–13, 16, 17	103	Villar, Choros, Casagrande, Szwilski	1, 2, 5–7, 10–13, 16, 17	
3, 8, 14	103	Villar, Choros, Casagrande, Szwilski, Khattak	3, 8, 14	
4, 9, 15	103	Villar, Choros, Casagrande, Szwilski, Andersson	4, 9, 15	
Overall Outcome			1–17	

V. ORDER

Accordingly, it is hereby:

ORDERED that claims 1–17 of the '320 patent have been proven to be *unpatentable*; and

FURTHER ORDERED that because this is a Final Written Decision, parties to this proceeding seeking judicial review of the Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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decision, we draw Patent Owner's attention to the April 2019 *Notice Regarding Options for Amendments by Patent Owner Through Reissue or Reexamination During a Pending AIA Trial Proceeding*. *See* 84 Fed. Reg. 16654 (Apr. 22, 2019). If Patent Owner chooses to file a reissue application or a request for reexamination of the challenged patent, we remind Patent Owner of its continuing obligation to notify the Board of any such related matters in updated mandatory notices. *See* 37 C.F.R. § 42.8(a)(3), (b)(2).

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