

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ERICSSON INC.
NOKIA OF AMERICA CORPORATION
Petitioners,

v.

XR COMMUNICATIONS LLC
Patent Owner.

U.S. PATENT NO. 8,737,511
Title: DIRECTED MIMO COMMUNICATIONS

Inter Partes Review No.: IPR2024-00868

PETITION FOR *INTER PARTES* REVIEW OF U.S. PAT. NO. 8,737,511

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TABLE OF CONTENTS

	Page
Full Listing of Challenged Claims' Language.....	1
Petitioners' Exhibit List	4
I. Introduction.....	6
II. Overview.....	6
III. Grounds for Standing (37 C.F.R. § 42.104(A)).....	9
IV. Reasons for the Requested Relief.....	9
A. Summary of the '511 Patent.....	9
B. Prosecution History	11
C. Claim Construction	13
D. Priority of the Challenged Claims.....	14
E. Person of Ordinary Skill in the Art	14
F. State of the Art	14
1. Antenna Arrays	15
2. MIMO	16
V. Identification of Challenges.....	17
A. Challenged Claims	17
B. Statutory Grounds for Challenges.....	17
C. Prior Art Basis	18
VI. the Challenged Claims are Unpatentable	18
A. Ground I: Claims 1-2, 4-6, 9-11, 13-15, and 18-20 are Obvious Over Trigui	18

1.	Trigui (Ex-1004)	18
2.	Detailed Application to the Challenged Claims	22
B.	Ground II - Claims 4-6, 9, 13-15, and 18 are Obvious Over Trigui in view of Rudrapatna	60
1.	Rudrapatna (Ex-1005).....	60
2.	Motivation to Combine Trigui and Rudrapatna.....	64
3.	Detailed Application to the Challenged Claims	65
VII.	The Board Should Not exercise Its Discretion to Deny Institution.....	68
A.	The Board Should Not Deny Institution Under 35 U.S.C. § 325	68
B.	The Board Should Not Deny Institution Under 35 U.S.C. § 314(a).....	69
VIII.	Mandatory Notices Under 37 C.F.R. §42.8.....	72
A.	Real-Party-in-Interest (37 C.F.R. §42.8(b)(1))	72
B.	Related Matters (37 C.F.R. §42.8(b)(2)).....	72
C.	Lead/Back-Up Counsel (37 C.F.R. §42.8(b)(3)):	73
D.	Notice of Service Information (37 C.F.R. §42.8(b)(4)):.....	73
IX.	Conclusion	73
	CERTIFICATION OF SERVICE ON PATENT OWNER.....	74
	CERTIFICATE OF COMPLIANCE.....	76

Full Listing of Challenged Claims' Language

[1pre]	1. A system comprising:
[1a]	m antenna arrays configured to receive a propagating radio frequency signal and configured to transmit a propagating radio frequency signal, each of the antenna arrays comprising: a plurality of antenna elements; and a beamformer configured to produce n different bi-directional beams using the plurality of antenna elements; and
[1b]	n multiple-input multiple-output transceivers (MIMO), each MIMO transceiver comprising: a MIMO receiver configured to process m different received signals, wherein an i-th received signal to a j-th MIMO receiver corresponds to a j-th beam of an i-th antenna array; and a MIMO transmitter configured to process m different transmit signals, wherein a v-th transmit signal from a z-th MIMO transmitter corresponds to a z-th beam of a v-th antenna array,
[1c]	wherein m, n, v, and z are integer number values, wherein $i=1, \dots, m$, $j=1, \dots, n$, and $v=1, \dots, m$, wherein $n \geq 2$ and $m \geq 2$, wherein $z=1, \dots, w$, and wherein $n \geq w \geq 2$.
[2]	The system of claim 1, configured to substantially comply with one or more of Electrical and Electronic Engineers (IEEE) 802.11 a/b/g/n/ac (WiFi), IEEE 802.16 (WiMAX), 2nd Generation Partnership Project (3GPP) Long Term Evolution (LTE), 3GPP LTE-Advanced, 3GPP LTE-TDD, 3GPP LTE-FDD, High Speed Packet Access (HSPA), and HSPA+.
[4]	The system of claim 1, wherein the m antenna arrays are separated by a distance more than one wavelength apart at the carrier frequency.
[5]	The system of claim 1, wherein the antenna elements are less than or equal to one half wavelength apart at the carrier frequency.
[6]	The system of claim 1, wherein the beamformer is an electronic beamformer.

[9]	The system of claim 1, wherein the system simultaneously provides MIMO and beamforming.
[10pre]	An apparatus comprising:
[10a]	m antenna arrays configured to receive a propagating radio frequency signal and configured to transmit a propagating radio frequency signal, each of the antenna arrays comprising: a plurality of antenna elements; and a beamformer configured to produce n different bi-directional beams using the plurality of antenna elements; and
[10b]	n multiple-input multiple-output transceivers (MIMO), each MIMO transceiver comprising: a MIMO receiver configured to process m different received signals, wherein an i-th received signal to a j-th MIMO receiver corresponds to a j-th beam of an i-th antenna array; and a MIMO transmitter configured to process m different transmit signals, wherein a v-th transmit signal from a z-th MIMO transmitter corresponds to a z-th beam of a v-th antenna array,
[10c]	wherein m, n, v, and z are integer number values, and wherein $i=1, \dots, m$, $j=1, \dots, n$, and $v=1, \dots, m$, wherein $n \geq 2$ and $m \geq 2$ wherein $z=1, \dots, w$, and wherein $n \geq w \geq 2$.
[11]	The apparatus of claim 10, configured to substantially comply with one or more of Electrical and Electronic Engineers (IEEE) 802.11a/b/g/n/ac (WiFi), IEEE 802.16 (WiMAX), 2nd Generation Partnership Project (3GPP) Long Term Evolution (LTE), 3GPP LTE-Advanced, 3GPP LTE-TDD, 3GPP LTE-FDD, High Speed Packet Access (HSPA), and HSPA+.
[13]	The apparatus of claim 10, wherein the m antenna arrays are separated by a distance more than one wavelength apart at the carrier frequency.
[14]	The apparatus of claim 10, wherein the antenna elements are less than one half wavelength apart at the carrier frequency.

[15]	The apparatus of claim 10, wherein the beamformer is an electronic beamformer.
[18]	The apparatus of claim 10, wherein the apparatus simultaneously provides MIMO and beamforming.
[19pre]	An apparatus comprising:
[19a]	m antenna arrays configured to receive a propagating radio frequency signal, each of the antenna arrays comprising: a plurality of antenna elements; and a beamformer configured to produce n different receive beams using the plurality of antenna elements; and
[19b]	n multiple-input multiple-output receivers (MIMO), each MIMO receiver configured to process m different received signals, wherein an i-th received signal to a j-th MIMO receiver corresponds to a j-th beam of an i-th antenna array,
[19c]	wherein m and n are integer number values, and wherein $i=1, \dots, m$, and $j=1, \dots, n$, and wherein $n \geq 2$ and $m \geq 2$.
[20pre]	An apparatus comprising:
[20a]	m antenna arrays configured to transmit a propagating radio frequency signal, each of the antenna arrays comprising: a plurality of antenna elements; and a beamformer configured to produce n different transmit beams using the plurality of antenna elements; and
[20b]	n multiple-input multiple-output transmitters (MIMO), each MIMO transmitter configured to process m different transmit signals, wherein a v-th transmit signal from a z-th MIMO transmitter corresponding to a z-th beam of a v-th antenna array is selected for transmission,
[20c]	wherein m, n, v, and z are integer number values, and wherein $z=1, \dots, n$, and $v=1, \dots, m$, and wherein $n \geq 2$ and $m \geq 2$.

Petitioners' Exhibit List

<i>Exhibit #</i>	<i>Description</i>
1001	U.S. Patent No. 8,737,511 (“’511 Patent”)
1002	Prosecution History for the ’511 Patent
1003	Declaration of Dr. Kevin Negus
1004	U.S. Patent Publication No. 2011/0150050 to Trigui et al. (“Trigui”)
1005	U.S. Patent No. 6,801,790 to Rudrapatna (“Rudrapatna”)
1006	A. Molisch, <i>Wireless Communications</i> , Second Edition, ISBN: 878-0-470-74187-0
1007	U.S. Patent Publication No. 2002/0132600 to Rudrapatna
1008	PCT Application No. WO 2011/078898 to Trigui et al.
1009	Plaintiff XR Communications, LLC’s Preliminary Disclosure of Asserted Claims and Infringement Contentions
1010	Jose Vilches, “Everything You Need to Know about 4G Wireless Technology,” (April 29, 2010), available at: https://www.techspot.com/guides/272-everything-about-4g/
1011	Joy Huang, Commscope, “Re-shaping Wind Load Performance for Base Station Antennas,” available at: https://www.commscope.com/globalassets/digizuite/762340-bsa-enhanced-wind-load-performance-wp-115177-en.pdf
1012	Philip Sorrells, “The Problems with Overweight Cell Towers,” (September 2, 2014), available at: https://www.commscope.com/blog/2014/the-problems-with-overweight-cell-towers/
1013	Columbia Telecommunications Corp., “Cellular Tower Requirements Study for Talbot County, Maryland” (April 2009), available at:

<i>Exhibit #</i>	<i>Description</i>
	https://talbotcountymd.gov/uploads/File/council/Cellular_Study_FINAL.pdf
1014	U.S. Patent Publication No. 2003/0032424 (“Judd”)
1015	U.S. Patent Publication 2008/0026796 (“Thomas”)
1016	PCT Application No. WO 92/12579 (“Prokkola”)

I. INTRODUCTION

Pursuant to 35 U.S.C. §§ 311 *et seq.* and 37 C.F.R. §§ 42.1 *et seq.*, Ericsson Inc. and Nokia of America Corporation (collectively “Petitioners”) hereby petition for an *inter partes* review (“IPR”) of U.S. Patent No. 8,737,511 (the “’511 Patent”). Petitioners respectfully submit that claims 1-2, 4-6, 9-11, 13-15, and 18-20 (the “Challenged Claims”) are unpatentable under 35 U.S.C. § 103 over the prior art herein. The primary reference, Trigui, was not considered during prosecution.

II. OVERVIEW

The Challenged Claims relate to a wireless system that includes both beam-forming by antenna arrays and multiple-input-multiple-output (“MIMO”) capabilities. The ’511 Patent’s priority date is in 2012. By 2012, beamforming and MIMO (including the combination thereof) was a well-developed technology.

Thus, to avoid the large body of known art, the ’511 Patent relies upon a very exacting architecture. This architecture requires specific relationships between the number of antenna arrays, the number of beams generated by each antenna array and the number of “MIMO transceivers” that must be connected to specific beams from specific antenna arrays. As detailed in Section IV.B, it was only this exacting, specific arrangement of components that allowed the ’511 claims to be issued.

In particular, the Challenged Claims require a specific number of multiple antenna arrays (“m antenna arrays”) that each produce a specific number of multiple beams (“n different [] beams”) connected to the same number (“n”) of multiple

MIMO transceivers¹ (“n multiple-input multiple-output transceivers (MIMO)”). The MIMO transceivers process multiple transmit and receive signals (“m different transmit signals” and “m different receive signals”), such that the number of beams (“n”) is equal to the number of MIMO transceivers and the number of antenna arrays (“m”) is equal to the number of transmit and receive signals processed by each MIMO transceiver. This is illustrated in the annotated version of Figure 2 below:

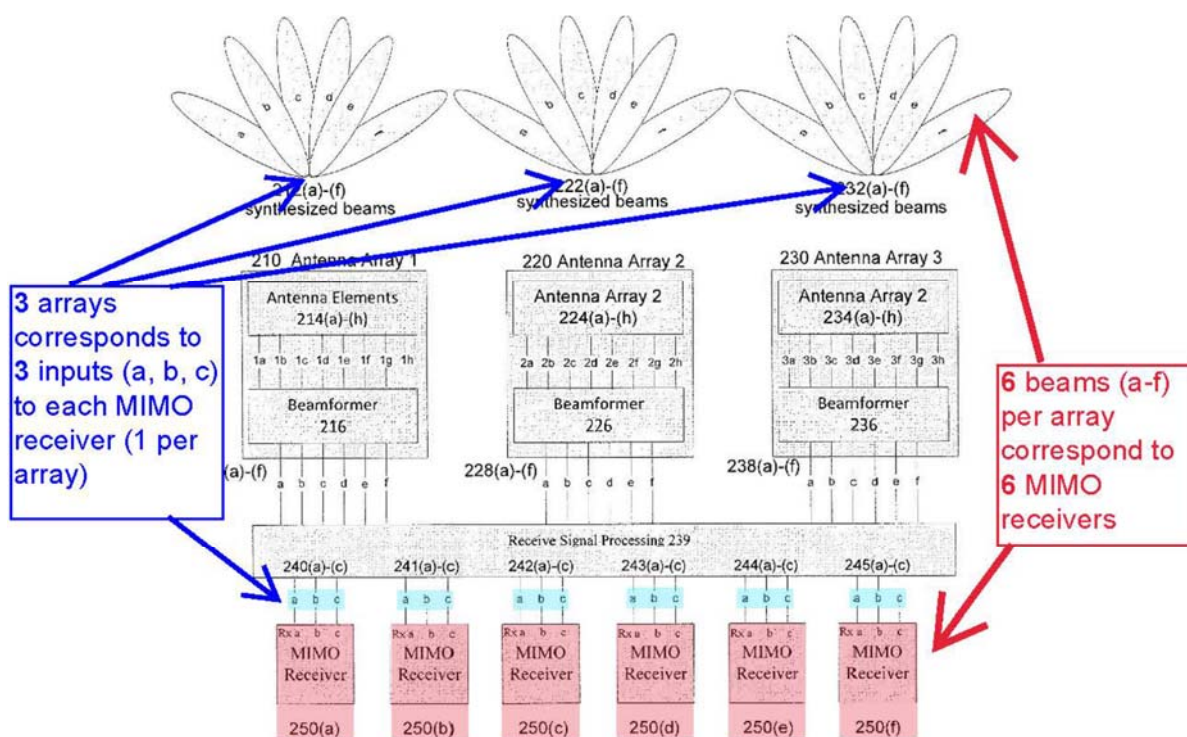


FIG. 2

During prosecution, the Applicant distinguished the prior art by arguing that the prior art did not disclose “the interconnection of multiple antenna arrays with

¹ Claims 19 and 20 require a MIMO receivers and MIMO transmitters, respectively, but as explained below in §VI, they only require a subset of the functionality of the MIMO transceivers recited in claim 1.

multiple beams to multiple MIMO transceivers each with multiple inputs and outputs.” Ex-1002.000092. The Applicant further argued that the prior art did not describe an implementation where “the number of beams per antenna array is equal to the number of MIMO transceivers” and “the number of inputs/outputs per MIMO transceiver is equal to the number of antenna arrays.” Ex-1002.000124.

As detailed in Ground I, the primary reference relied on here (Trigui, Ex-1004) teaches the concept of multiple MIMO transceivers that process multiple transmit and receive signals, and further discloses multiple antenna arrays that produce multiple beams. Trigui further teaches that the multiple antenna arrays with multiple beams are interconnected with the multiple MIMO transceivers, and further teaches the scenario where the number of beams per antenna array is equal to the number of MIMO transceivers and the number of inputs/outputs per MIMO transceiver is equal to the number of antenna arrays.

Finally, as detailed in Ground II, the Challenged Claims include a series of dependent claims that recite well-known antenna limitations that are taught by a secondary prior art reference (Rudrapatna, Ex-1005). During prosecution, the Examiner relied on the published patent application of Rudrapatna to invalidate these dependent claims, and the Applicant never disputed that Rudrapatna taught the additional limitations of the dependent claims.

Petitioners respectfully request that the Board institute IPR and cancel the Challenged Claims.

III. GROUNDS FOR STANDING (37 C.F.R. § 42.104(A))

Petitioners certify that the '511 Patent is available for IPR and Petitioners are not barred or estopped from requesting this review. 37 C.F.R. §42.104(a). This Petition is filed under 37 C.F.R. §42.106(a).

IV. REASONS FOR THE REQUESTED RELIEF

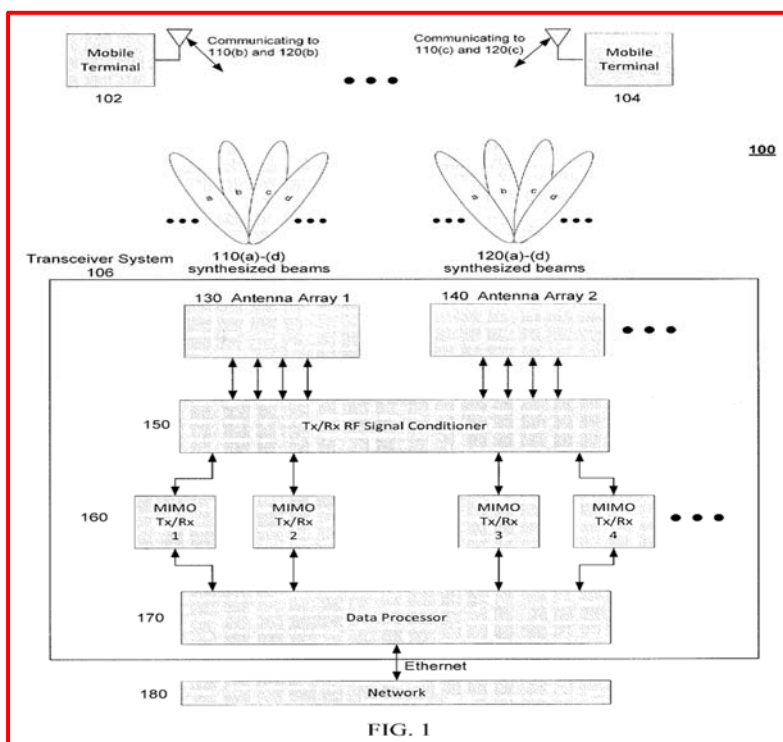
As explained here and in the Declaration of Petitioner's Expert, Dr. Kevin Negus (Ex-1003), the systems/methods claimed in the '511 Patent were obvious over the prior art to a person of ordinary skill in the art ("POSA") at the time of the invention.

A. Summary of the '511 Patent

The '511 Patent "relates to multiple-input multiple-output (MIMO) wireless communications and beamforming antennas." Ex-1001, 1:5-7. It explains that MIMO wireless communication systems "utilize multiple transmit antennas and multiple receive antennas instead of a single antenna" and these systems "often have multiple transmitters (e.g., one associated with each transmit antenna) and multiple receivers (e.g., one associated with each receive antenna)." *Id.*, 1:11-16. The '511 Patent explains that a "transceiver" is something that may "modulate transmit signals and demodulate receive signals and may perform further processing of receive signals after demodulation and of transmit signals prior to modulation" and describes "beamforming" as "utiliz[ing] multiple antenna elements and often a beamformer to

synthesize one or more beams” where “a beamforming antenna can be called an antenna array.” *Id.*, 1:16-24.

The '511 Patent discloses a system and apparatus that includes “a plurality of m antenna arrays configured to receive a propagating radio frequency signal” and this “provides many advantages” because “MIMO and beamforming can be combined to provide range extension and throughput enhancement supported at either or both of a base station and mobile terminal.” *Id.*, 1:28-30, 1:60-62, 2:4-6, 2:17-22. Figure 1 (below) discloses a block diagram of a transceiver for extended communications range and throughput using MIMO and beamforming:



Ex-1001, 2:54-6, Fig. 1. Mobile terminals 102, 104 are in communications range with the transceiver system 106, where two multi-beam antenna arrays 130, 140 each communicate with both mobile terminals. *Id.*, 2:56-59. Signals received from the

mobile terminals and signals transmitted to the mobile terminals are processed by “transceiver radio frequency signal conditioner (Tx/RF signal conditioner) 150 and passed from/to MIMO transceivers 160 where the received signals are transformed into receive data and transmit data is transformed into transmit signals.” 2:59-66.

B. Prosecution History

Application No. 13/447,139, which became the ’511 Patent, was filed on April 13, 2012. Original claims 1-3 are reproduced below:

1. A system comprising:
 - a plurality of m antenna arrays configured to receive a propagating radio frequency signal, each of the antenna arrays comprising:
 - a plurality of antenna elements; and
 - a beamformer configured to produce n different bi-directional beams using the plurality of antenna elements; and
 - a plurality of n multiple-input multiple-output transceivers (MIMO), each MIMO transceiver comprising:
 - a MIMO receiver configured to accept m received signals, wherein the i-th input signal to the j-th MIMO receiver corresponds to the j-th beam of the i-th antenna array; and
 - a MIMO transmitter configured to provide m transmit signals, wherein the v-th output signal from the z-th MIMO transmitter corresponding to the z-th beam of the v-th antenna array is selected for transmission,
 - wherein m, n, v, and z are integer number values, and
 - wherein $i=1, \dots, m$, $j=1, \dots, n$, and $v=1, \dots, m$.
2. The system of claim 1, wherein $z = [\text{one value between 1 and } n]$.
3. The system of claim 1, wherein $z = 1, \dots, n$.

Ex-1002.000021. The PTO rejected all pending claims, including rejecting claim 1 over U.S. Patent Pub. 2009/0322608 (“Adams”) and U.S. Patent Pub. 2002/1032600

(“Rudrapatna”). Ex-1002.000064-.000073, .000067. The Applicant amended claim 1 as illustrated below:

1. (Currently Amended) A system comprising:

a plurality of ~~m~~ antenna arrays configured to receive a propagating radio frequency signal and configured to transmit a propagating radio frequency signal, each of the antenna arrays comprising:

a plurality of antenna elements; and

a beamformer configured to produce ~~n~~ different bi-directional beams using the plurality of antenna elements; and

a plurality of ~~n~~ multiple-input multiple-output transceivers (MIMO), each MIMO transceiver comprising:

a MIMO receiver configured to accept ~~m~~ received signals, wherein the ~~i~~-th input signal to the ~~j~~-th MIMO receiver corresponds to the ~~j~~-th beam of the ~~i~~-th antenna array; and

a MIMO transmitter configured to provide ~~m~~ transmit signals, wherein the ~~v~~-th output signal from the ~~z~~-th MIMO transmitter corresponding to the ~~z~~-th beam of the ~~v~~-th antenna array is selected for transmission,

wherein ~~m~~, ~~n~~, ~~v~~, and ~~z~~ are integer number values, ~~and~~

wherein ~~i~~=1, ..., ~~m~~, ~~j~~=1, ..., ~~n~~, and ~~v~~=1, ...~~m~~, and

wherein $n \geq 2$ and $m \geq 2$.

Id., .000082. The Applicant also stated in remarks that Adams does not “disclose or suggest the interconnection of multiple antenna arrays with multiple beams to multiple MIMO transceivers each with multiple inputs and outputs, much less the interconnection of components as recited in claim 1.” *Id.*, .000092.

The Examiner rejected the claims again over Adams and Rudrapatna. *Id.*, .000096-.000107. The Applicant amended claim 1 again, as follows:

1. (Currently Amended) A system comprising:

m antenna arrays configured to receive a propagating radio frequency signal and configured to transmit a propagating radio frequency signal, each of the antenna arrays comprising:

a plurality of antenna elements; and

a beamformer configured to produce n different bi-directional beams using the plurality of antenna elements; and

n multiple-input multiple-output transceivers (MIMO), each MIMO transceiver comprising:

a MIMO receiver configured to ~~accept~~ process m different received signals, wherein ~~the an i-th input received signal to a the j-th MIMO receiver corresponds to the a j-th beam of an the i-th antenna array; and~~

a MIMO transmitter configured to ~~provide~~ process m different transmit signals, wherein ~~the a v-th output transmit signal from the a z-th MIMO transmitter eorresponding corresponds to the a z-th beam of the a v-th antenna array-is selected for transmission,~~

wherein m, n, v, and z are integer number values,

wherein $i=1, \dots, m, j=1, \dots, n$, and $v=1, \dots, m$, and

wherein $n \geq 2$ and $m \geq 2$.

Id., .000115. The Applicant further stated “nowhere does Adams describe an implementation where the number of beams per antenna array is equal to the number of MIMO transceivers” and “nowhere does Adams describe an implementation where the number of inputs/outputs per MIMO transceiver is equal to the number of antenna arrays.” *Id.*, .000124. The claims were subsequently amended following an Examiner interview and, after an Examiner’s amendment, allowed. *Id.*, .000141-.000149, .000179, .000197-.000207.

C. Claim Construction

For this IPR, Petitioner proposes that each claim term of the Challenged Claims be given its “ordinary and customary meaning” as understood by a POSA at

the time of the claimed invention. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312, 1327 (Fed. Cir. 2005). No specific construction of any term is required because the prior art relied on here meets each limitation under any reasonable construction. Ex-1003, ¶92.

D. Priority of the Challenged Claims

The '511 Patent was filed on April 13, 2012. Ex-1001, (22). In District Court, Patent Owner has alleged that the '511 Patent is entitled to a priority date at least as early as April 13, 2012. Ex-1009, p. 6. Petitioners rely on references that are prior art as of the April 13, 2012 filing date of the '511 Patent.

E. Person of Ordinary Skill in the Art

A POSA would have had at least a Bachelor's degree in Electrical Engineering or a related field and at least two years of professional experience in developing MIMO-based wireless communications products. Ex-1003, ¶¶24-25. Alternatively, a POSA could have had a more advanced degree, such as a Master's degree in Electrical Engineering or an equivalent field, combined with at least one year of work experience in developing MIMO-based wireless communications products. *Id.*

F. State of the Art

This section describes the state of the art, general knowledge, skill, common sense, and creativity possessed by a POSA as of April 2012, and explains the conventional purposes, methods, and components in the art, informing the motivations and reasonable expectations of success.

1. Antenna Arrays

Antenna arrays (or array antennas) were often used for base stations in cellular systems because they resulted in antenna patterns that could be “more easily shaped.” Ex-1006, p. 175; Ex-1003, ¶151. This shaping could be done in a “predetermined way” or “adaptively,” and the “pattern of an antenna array” could be written as the product of a single antenna element and “the array factor.” Ex-1006, p. 175. The array factor of a uniform linear antenna array is written below, and “ d_a is the distance between antenna elements,” and “ w_n are the complex weights of element excitations,” and λ is the wavelength of the RF carrier.

$$M(\phi) = \sum_{n=0}^{N_T-1} w_n \exp [-j \cos(\phi) 2\pi d_a n / \lambda] \quad (9.16)$$

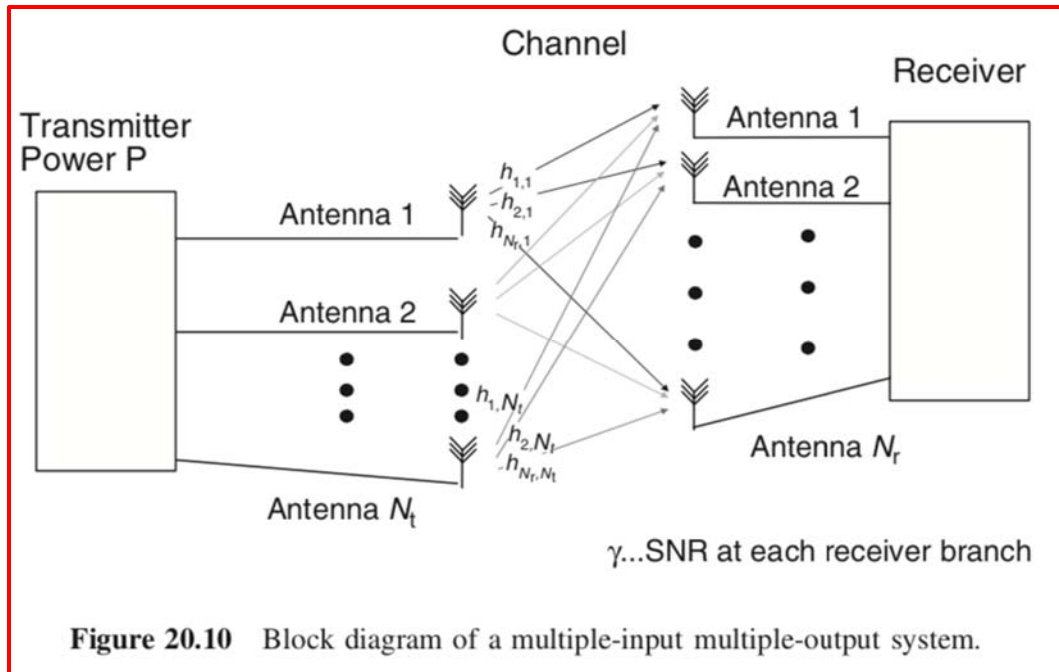
Ex-1006, p. 175, eq. 9.16. For such an array antenna, the distance between antenna elements is usually chosen as $d_a = \lambda/2$, where λ is the wavelength, because “ $d_a \leq \lambda/2$ is necessary to avoid spatial aliasing.” *Id.*, pp. 38, 175.

For cellular communications, cellular service providers (also called “operators”) frequently shared “towers” that “serve[d] as access points for communicating with subscribers’ handheld and mobile cellular devices.” Ex-1013.000003, .000010. Operators could share towers by having their own antenna arrays on a given tower, but this had drawbacks such as increasing the weight on a tower, increasing the wind resistance, and increased ice formation. Ex-1014, [0004].

Having operators share antenna arrays on cell towers was a known solution to this problem. Ex-1014, [0026] (disclosing sharing antenna arrays between service providers); Ex-1015, at [0002] (“Antenna sharing provides a solution to the problem of limiting site and antenna numbers”), [0003] (explaining that Ex-1016 discloses “an antenna system for shared operation by multiple operators”); Ex-1016, (22) (published in 1992), 2:40-45 (disclosing “a common antenna and a common-antenna filter [] used for the base stations of mobile telephone systems of different types”).

2. MIMO

MIMO systems have multiple element antennas at both link ends, and these multiple element antennas can be used for different purposes: (1) beamforming, (2) diversity, (3) interference suppression, and (4) spatial multiplexing. Ex-1006, pp. 464-65. Spatial multiplexing in particular “allows direct improvement of capacity by simultaneous transmission of multiple data streams.” *Id.*, p. 465. In a generic MIMO system, illustrated below, a data stream at the transmitter enters an encoder, whose outputs are forwarded to the multiple transmit antennas, transmitted, and are received by multiple receive antennas. Ex-1006, p. 466.



Id., p. 466, Fig. 20.10. However, “[c]orrelation of the signals at different antenna elements can significantly reduce the capacity of a MIMO system,” and this correlation “is influenced by the angular spectrum of the channel as well as the arrangement and spacing of antenna elements.” *Id.*, pp. 473-74; Ex-1003, ¶¶159-161. For base stations in cellular systems, “the antenna spacing required to obtain sufficient decorrelation increases” and that “antenna spacing has to be on the order of 2-20 wavelengths.” Ex-1006, pp. 252-253.

V. IDENTIFICATION OF CHALLENGES

A. Challenged Claims

Claims 1-2, 4-6, 9-11, 13-15, and 18-20 are challenged in this Petition.

B. Statutory Grounds for Challenges

The Challenges are set forth in detail below and summarized as follows:

Ground	Claim(s)	Basis	Reference
1	1-2, 4-6, 9-11, 13-15, and 18-20	§103	Trigui in view of the knowledge of a POSA
2	4-6, 9, 13-15, and 18	§103	Trigui in view of Rudrapatna and the knowledge of a POSA

C. Prior Art Basis

U.S. Patent Publication No. 2011/0150050 (“Trigui”) was filed on December 23, 2009 and published June 23, 2011. Ex-1004, (22), (43), (54), (76). Trigui is prior art to the ’511 Patent under at least §§102(a)(e).

U.S. Patent No. 6,801,790 (“Rudrapatna”) was filed on January 17, 2001 and issued October 5, 2004. Ex-1005, (22), (45). (54), (75). Rudrapatna is prior art under at least §102(a)(b)(e).

VI. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground I: Claims 1-2, 4-6, 9-11, 13-15, and 18-20 are Obvious Over Trigui

1. Trigui (Ex-1004)

a. Analogous Art

Trigui teaches “using a digitally integrated antenna array for enhancing coverage and capacity of a wireless network” and for “sharing antenna elements and active electronics between multiple operators servicing the same geographic area.”² Ex-1004, [0002]. Trigui explains that “[a] key factor in network design is the cost per bit of transmitted data” and “[a] partial solution to this problem” is “adopting the

² As used herein, “discloses” or “teaches” encompasses what a reference would teach, suggest or otherwise render obvious to a POSA in view of the prior art.

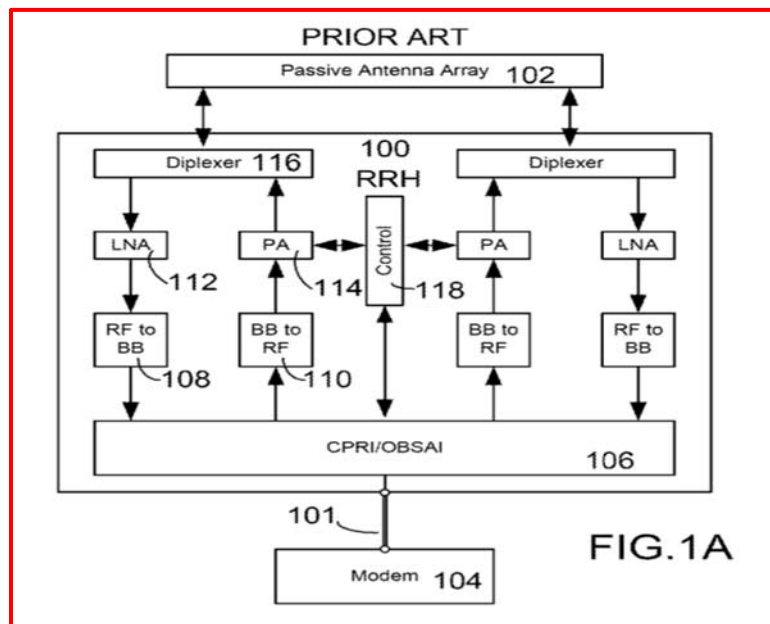
most spectrally efficient air interface” and “multiple input multiple output (MIMO) antenna techniques by an advanced wireless system such as WiMAX or 3rd Generation Partnership Project Long Term Evolution (3GPP LTE).” Ex-1004, [0004]. Trigui further explains that “[b]eamforming is a general signal processing technique used to control the directionality of the reception or transmission of a signal on a transducer array” in “a chosen angular direction.” Ex-1004, [0015].

Trigui is analogous art, is in the same field of endeavor, and is reasonably pertinent to the problem addressed by the '511 Patent because Trigui's solution includes “integrat[ing] a passive antenna array with radio transceivers in a single physical package and [distributing] the design to increase the degrees of freedom to offer more control flexibility.” Ex-1004, [0020]; Ex-1003, ¶¶96, 102-103.

b. Overview of Trigui

Trigui discusses a conventional approach to reducing RF losses and enabling “versatile capacity and network level optimization solutions using a remote radio head (‘RRH’) implementing a 2x2 MIMO system.” Ex-1004, [0005]. Figure 1A shows a conventional approach with a single modem 104 “connected via a fiber optic interface 101 to an RRH 100.” *Id.*, [0006]. The RRH, connected to a passive antenna array 102 for transmitting/receiving RF signals, has electronic components for converting signals from baseband to RF (and vice versa), as well as amplification circuitry for transmission and reception. *Id.*, [0006-0008]. Figure 1A shows a 2x2 MIMO system “in which [a] pair of transmission/reception paths are multiplexed”

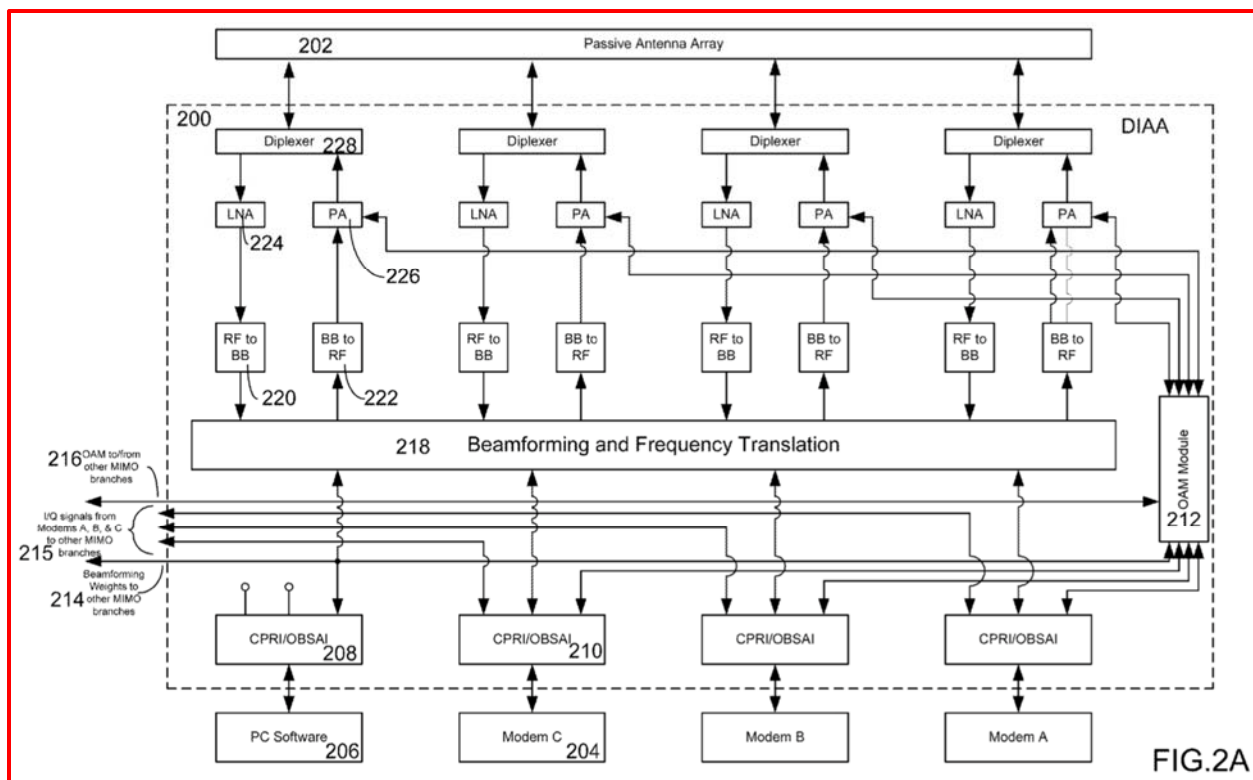
such that, for transmission, “digital signals received from the modem 104 are demultiplexed, converted to RF, routed to the two power amplifiers, and finally to the passive antenna array 102.” *Id.*, [0009]. Similarly, received signals “along the two reception paths are multiplexed before being transmitted via the optical fiber cable 101 to the modem 104.” *Id.* Further, “interference cancellation algorithms are implemented at the baseband for each active user,” making cancelling interfering signals in the uplink and reducing the probability of interference in the downlink possible. *Id.*, [0014].



Trigui explains that “per user beamforming” could be facilitated by developing more expensive base stations that provide meaningful benefits in only certain cases, but a “more economical” solution, which also addresses problems such as “unbalanced traffic demand[s] across the network,” is “sub-sectorization” using an antenna array “to create sub-sectors with specified radiation patterns[.]” *Id.*,

[0016-0017]. Trigui's solution is to "integrate a passive antenna array with radio transceivers in a single physical package" to "distribute the design to increase the degrees of freedom to offer more control flexibility." *Id.*, [0020].

Trigui discloses a "digital integrated antenna array" ("DIAA") system with "one or more antenna modules, one or more transceiver modules each having one or more signal processing paths for transmitting data to or receiving data from the one or more antenna modules, and a signal processing unit able to process data" for each of "the one or more signal processing paths of the one or more transceiver modules." *Id.*, [0021]. Figure 2A shows a "general high-level implementation" of a DIAA with a single branch of a DIAA system, and what Trigui calls a "2xN MIMO DIAA," where "N is the number of transceivers at the subscriber station." *Id.*, [0036]. Figure 2A depicts DIAA 200 and "one or more modems 204 [. . .] connected via one or more fiber optic interfaces, respectively to one or more digital interface cores 208, 210 within the DIAA." *Id.*, [0037-0038]. The digital interface cores are connected to a "server based software interface 206," which calculates ideal beamforming weights that approximate a desired radiation pattern, and passes these weights to the DIAA. *Id.* While Figure 2A "illustrates only a single MIMO branch DIAA", Trigui "contemplates the use of multiple MIMO branches" so that "I/Q signals 215 from any of the modems, as well as the beamforming weights 214, can be sent to other MIMO branches." *Id.*, [0041].



Trigui explains that “exemplary implementations of 4xN MIMO DIAAs, essentially including multiples” of the hardware of Figure 2A, are illustrated in Figures 7-11. *Id.*, [0036]. According to Trigui, the use of MIMO DIAAs “enabl[es] multiple operator sharing of a passive antenna array, transceivers, and the total available power of the DIAA,” where “splitting resources between the multiple operators is flexible and should be done on the basis of individual operator needs.” *Id.*, [0048].

2. Detailed Application to the Challenged Claims

a. Claim 1

[1pre] A system comprising:

Trigui discloses systems using a DIAA and a 4xN MIMO DIAA system for cellular base stations. Ex-1004, [0036]-[0038], [0082-[0085]; Ex-1003, ¶¶172-174.

[1a] m antenna arrays configured to receive a propagating radio frequency signal and configured to transmit a propagating radio frequency signal, each of the antenna arrays comprising:

a plurality of antenna elements; and

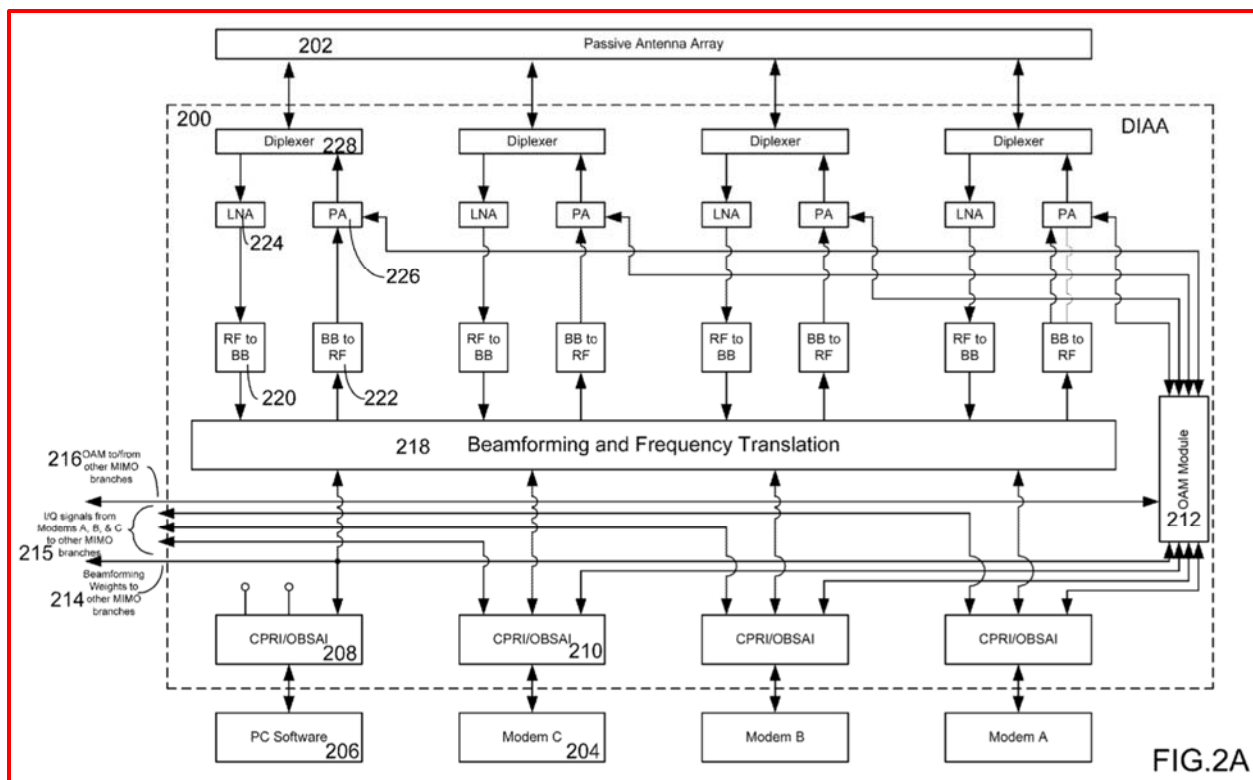
a beamformer configured to produce n different bi-directional beams using the plurality of antenna elements; and

Trigui discloses this limitation. Ex-1003, ¶¶176-199.

A POSA would understand: (1) because “ $m \geq 2$ ” and “ $n \geq 2$ ” (limitation [1c]), this limitation requires two or more antenna arrays each with two or more bi-directional beams (Ex-1003, ¶¶176, 178-179) and (2) the plain and ordinary meaning of “antenna element” includes a structure that radiates or receives radio waves (Ex-1003, ¶177; Ex-1001, 4:5-9). Trigui discloses these elements as detailed below.

- i. “each of the antenna arrays comprising: a plurality of antenna elements”

Trigui discloses a DIAA system “having one or more antenna modules.” Ex-1004, [0020]-[0021]. Figure 2A shows a DIAA which “represents a single MIMO branch of a DIAA system” and includes a “passive antenna array 202.” Ex-1004, [0036, 0038]; Ex-1003, ¶¶180-181.



Trigui further explains that the antenna arrays may consist of “sub-arrays” where “the antenna elements of each sub-array are combined passively to achieve a predefined pattern,” and that in this arrangement “the antenna array elements are closely spaced to avoid grating lobes when steering a beam off boresight direction.” Ex-1004, [0050]; Ex-1003, ¶185. Similarly, Trigui’s claims 1 and 2 recite “one or more antenna modules” that “include columns or groups of passive antenna elements.” Ex-1004, claims. 1-2; Ex-1003, ¶185.

A POSA would thus understand that Trigui’s description of the DIAA discloses at least “a plurality of antenna elements.” Ex-1003, ¶186.

- ii. “each of the antenna arrays comprising: . . . a beamformer configured to produce n different bi-directional beams using the plurality of antenna elements”

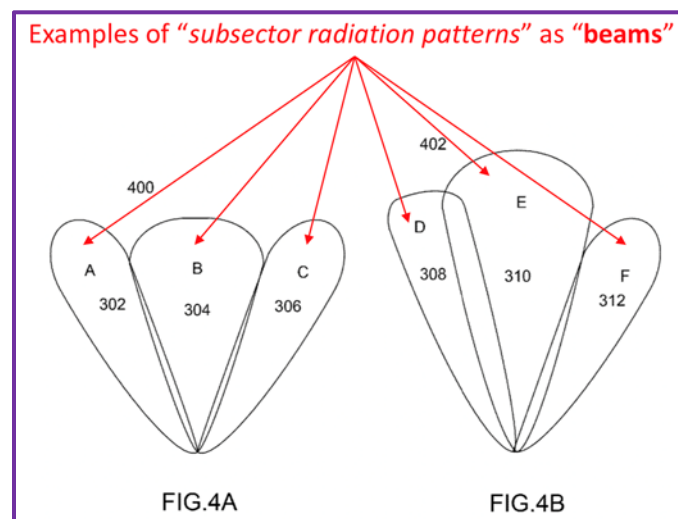
Trigui discloses that each antenna array includes a *beamformer*. Ex-1003, ¶¶182-184, 186. Trigui explains that “server based software calculates the ideal beamforming weights 214 that best approximate the desired radiation pattern and the weights are passed to the DIAA.” Ex-1004, [0038]. In the transmit direction, signals from modems 204 are transmitted to a beamforming and frequency translation module 218, where they are “multiplied by the beamforming and calibration weights such that when applied to the passive antenna array 202, a user-specified radiation pattern is formed; the user-specified radiation pattern may have one or more subsector radiation patterns” (*bi-directional beams*). Ex-1004, [0044]; Ex-1003, ¶¶182-183. After processing in the beamforming and frequency translation module 218, these modem signals “are passed through a circuit 220 for converting the baseband signals to RF signals and then passed through a power amplifier 226” and then subsequently “passed through a diplexer 228 before being transmitted to the passive antenna array 202.” Ex-1004, [0045].

Similarly, in the receive direction, received signals on the same beams as used for transmit are passed from the antenna array back to the beamforming and frequency translation module where “beamforming and calibration weights are applied to the received signals to form modem signals.” Ex-1004, [0046]; Ex-1003, ¶184. “Generally speaking, transmit and receive beamforming weights for each

modem are the same.” Ex-1004, [0055]. Thus, the beams are “*bi-directional*” because the same beams are used for transmit and receive because the same weights are applied for transmit and receive. *See also* Ex-1004, [0077] (“each MIMO transceiver branch has one beam for transmit and receive”).

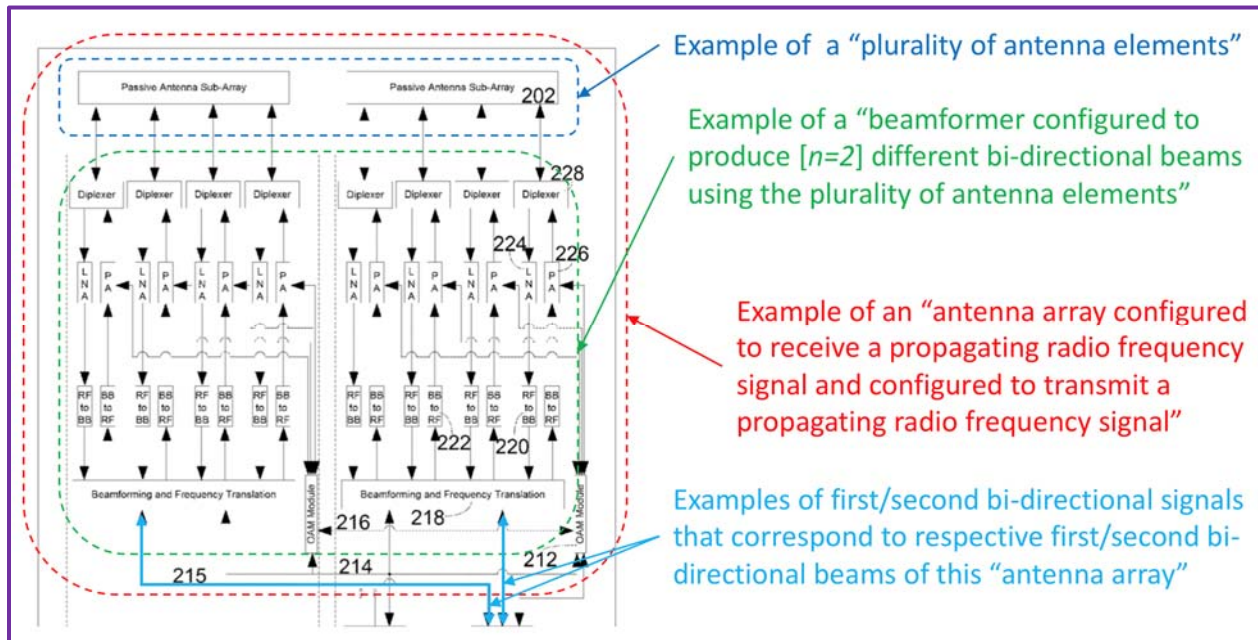
Accordingly, a POSA would understand that Trigui discloses a “beamformer” for forming bi-direction beams that includes “beamforming” module 218 in Figure 2A, alone or in combination with the circuits for converting: (1) baseband signals to RF signals in the transmit direction, and (2) RF signals to baseband in the receive direction. Ex-1003, ¶186.

Each of Trigui’s arrays can produce multiple beams (*n different bi-directional beams*). For example, Figures 4A and 4B, annotated by Dr. Negus below, each shows a configuration of 3 beams being generated by a single array. Ex-1004, [0062]; Ex-1003, ¶¶187-188.



Trigui's Figure 6 effectively uses two copies of Figure 2. Ex-1004, [0081].

In Figure 6 (as annotated below), each of the “sub-arrays” creates a bi-directional beam such that the array in Figure 6 generates 2 *different bidirectional beams* (“ $n=2$ ”).



Ex-1004, Fig. 6; Ex-1003, ¶¶189, 192.

Figure 6 teaches two bi-directional beams. “FIG. 6 illustrates two MIMO branches.” Ex-1004, [0081]. “Each MIMO transceiver branch has one beam for transmit and receive.” Ex-1004, [0077]. Thus, Figure 6 has two beams for transmit and receive. This is consistent with a POSA’s understanding of Figure 6. Ex-1003, ¶193; Ex-1004, [0074], [0009], [0014].

A POSA would thus understand that Trigui’s “beamforming” module (beamforming module 218 alone or in combination with other circuitry) teaches a

“beamformer configured to produce” multiple “different bi-directional beams using the plurality of antenna elements.” Ex-1003, ¶¶188, 193.

- iii. “m antenna arrays configured to receive a propagating radio frequency signal and configured to transmit a propagating radio frequency signal”

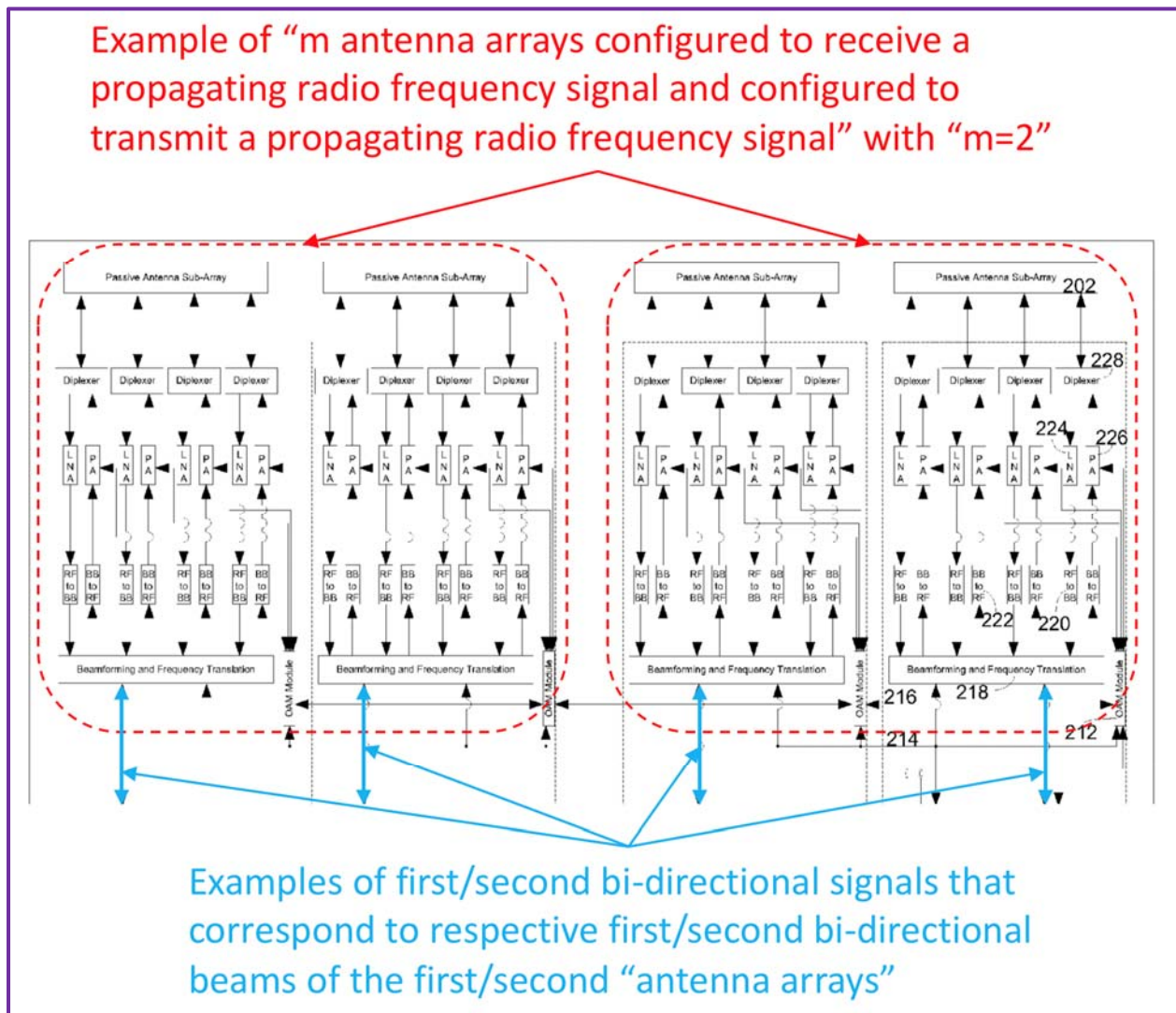
Trigui teaches that a system with multiple antenna arrays. Ex-1003, ¶¶194-195. As noted immediately above, Figure 6 shows a single antenna array with two beams. Trigui teaches that Figure 6 is replicated twice to produce, for example, Figure 10. Thus, Figure 10 shows two antenna arrays that each produce two beams as detailed below.

Trigui explains Figures 6-11 in terms of “MIMO.” As explain in Section IV.F.2, MIMO involves different “branches” (or “streams”) being transmitted between different antennas (or sets of antennas). Typically, MIMO is referenced as “AxB” where A is the number of transmit antennas (or sets of antennas) and B is the number of receive antennas (or sets of antennas). So, for example, in a 2x2 MIMO system, there are 2 transmit antennas (or sets of antennas if beamforming is done) and 2 receive antennas (or sets of receive antennas if beamforming is done).

“FIG. 6 illustrates a 2×N MIMO DIAA system.” Ex-1004, [0081]. Figure 6 shows “2xN” because each of the 2 sub-arrays is used for a different MIMO branch. “FIG. 6 illustrates two MIMO branches configured to provide a 2×N MIMO DIAA system.” *Id.*

Figures 7-11 replicate Figure 6's array with two sub-arrays (e.g., two copies) to each disclose a "4xN MIMO DIAA." Ex-1004, [0081-0086]; Ex-1003, ¶194.

As detailed above, Figure 6 shows a single antenna with two beams. Thus, using Dr. Negus's annotated Figure 10 below, replicating Figure 6 results in two antenna arrays (*m antenna arrays* where $m=2$) each outlined in red. *Id.*, ¶¶196-197.



Ex-1004, Fig. 10; Ex-1003, ¶196.

Thus, combining discussion above, a POSA would understand that Trigui teaches a system with *m antenna arrays* (where $m=2$ as shown above) each with a

beamformer configured to produce n different bi-directional beams (where n=2 beams) using the plurality of antenna elements (each sub-array in each array produces a different beam). Ex-1003, ¶¶197-199.

[1b] n multiple-input multiple-output transceivers (MIMO), each MIMO transceiver comprising:

a MIMO receiver configured to process m different received signals, wherein an i-th received signal to a j-th MIMO receiver corresponds to a j-th beam of an i-th antenna array; and

a MIMO transmitter configured to process m different transmit signals, wherein a v-th transmit signal from a z-th MIMO transmitter corresponds to a z-th beam of a v-th antenna array,

Trigui teaches this limitation. Ex-1003, ¶¶213-254.

The language of this limitation requires: (1) the same number (“n”) of “MIMO transceivers” as there are “beams” for each array in limitation [1a]; and (2) that each MIMO transceiver be connected to one bi-directional beam from each of the “m” arrays in limitation [1a].

For context, the ’511 patent depicts this arrangement (disclosing MIMO receivers, rather than the claimed MIMO transceivers, but making the same point) in Figure 2. Figure 2 discloses a system in which there are 6 beams “a-f” and 6 MIMO receivers “a-f” (*i.e.*, for both, n=6) and each MIMO receiver has 3 signal inputs (a, b and c) -- one from each of 3 antenna arrays (*i.e.*, for both, m=3).³

³ The ’511 patent claims this specific arrangement of “m=3 and n=6” shown for Fig. 2 in claim 3 (which is not challenged herein)

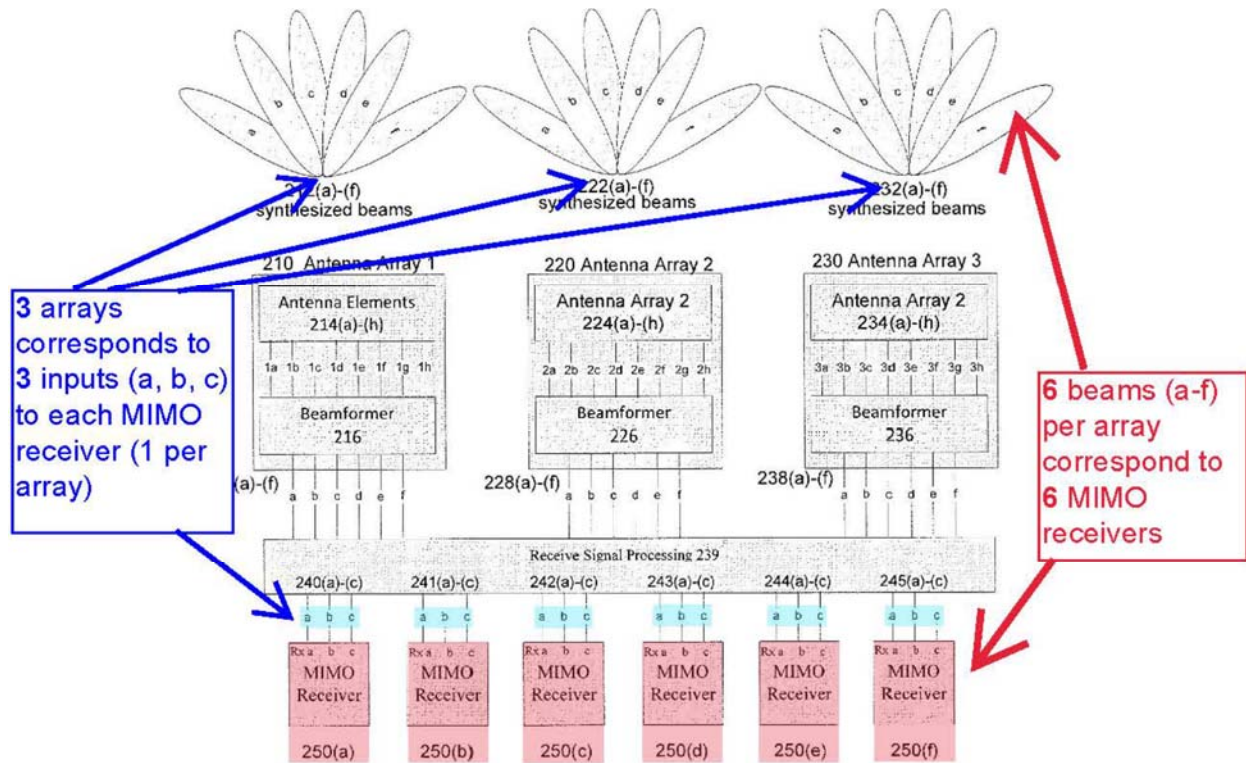
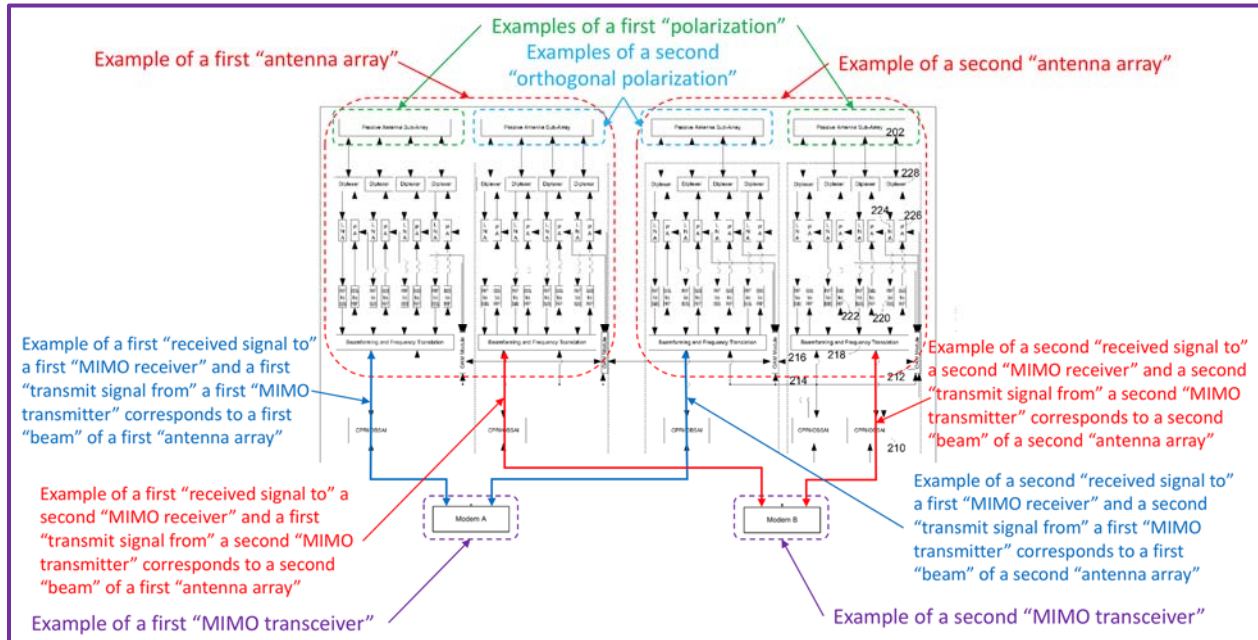


FIG. 2

Ex-1001, Fig. 2. As discussed in more below for limitation 1[c], the only limitations for “n” and “m” is that they are numbers greater than 1; *i.e.*, there is no relationship between the two variables.

Trigui likewise teaches the claimed arrangement of MIMO transceivers connected to beams and arrays. As detailed in [1a] above, Trigui’s Figure 10 discloses a system that includes two antenna arrays that each generate two beams (*i.e.*, $n=2$ for both antenna arrays). Additionally, as shown in the further annotated version of Figure 10 below, Trigui’s Figure 10 discloses two MIMO transceivers with two inputs that correspond to a beam from each of the two antenna arrays (*i.e.*, $m=2$ for both). Ex-1003, ¶¶251-253.

Thus, Trigui would teach this claim element by teaching that there are two MIMO transceivers (to match the number of beams per array) and that each MIMO transceiver has two inputs/outputs (one input/output from/to each array). That teaching is illustrated further by annotated Figure 10 of Trigui:



Ex-1004, Fig. 10; Ex-1003, ¶¶251-253. As explained above for [1a], a POSA would understand Trigui to teach **two antenna arrays** (in red). Each antenna array has two beams (a **blue polarized beam** and a **green polarized beam**). A POSA would understand that there are two MIMO transceivers (Modems A and B)⁴, as annotated above and explained below in limitation [1b].i.(b), with each MIMO transceiver having 2 inputs/outputs (one input/output from/to each of the two arrays). Thus,

⁴ Figure 10 of Trigui only discloses one modem, Modem A. However, as explained in the next paragraph, in [1b].i.(b), and by Dr. Negus, a POSA would understand from Trigui's disclosure of multiple operators sharing antenna arrays that each operator would have its own modem.

Trigui teaches this claim element regarding the “interconnection” of beams, arrays, and MIMO transceivers as detailed below in [1b].ii.

With regard to Modems A and B, while Figure 10 only discloses one modem, Trigui teaches (and provides a motivation) to have two “modems” that are each connected to the two arrays. Trigui teaches use cases in which two separate wireless network operators would share certain tower components, such as the antenna arrays,⁵ but each wireless network operator would have its own baseband unit (*i.e.*, modems A for the first operator and B for the second operator).⁶ Thus, with two operators sharing the antenna array, there would be two modems (MIMO transceivers) connected to one of the two beams in each of the two arrays. *See also infra* VI.A.2.a.[1b](i)(b).

i. “n multiple-input multiple-output transceivers (MIMO)”

(a) MIMO transceiver

Trigui teaches modems (or baseband modules) that include a “MIMO transceiver.”

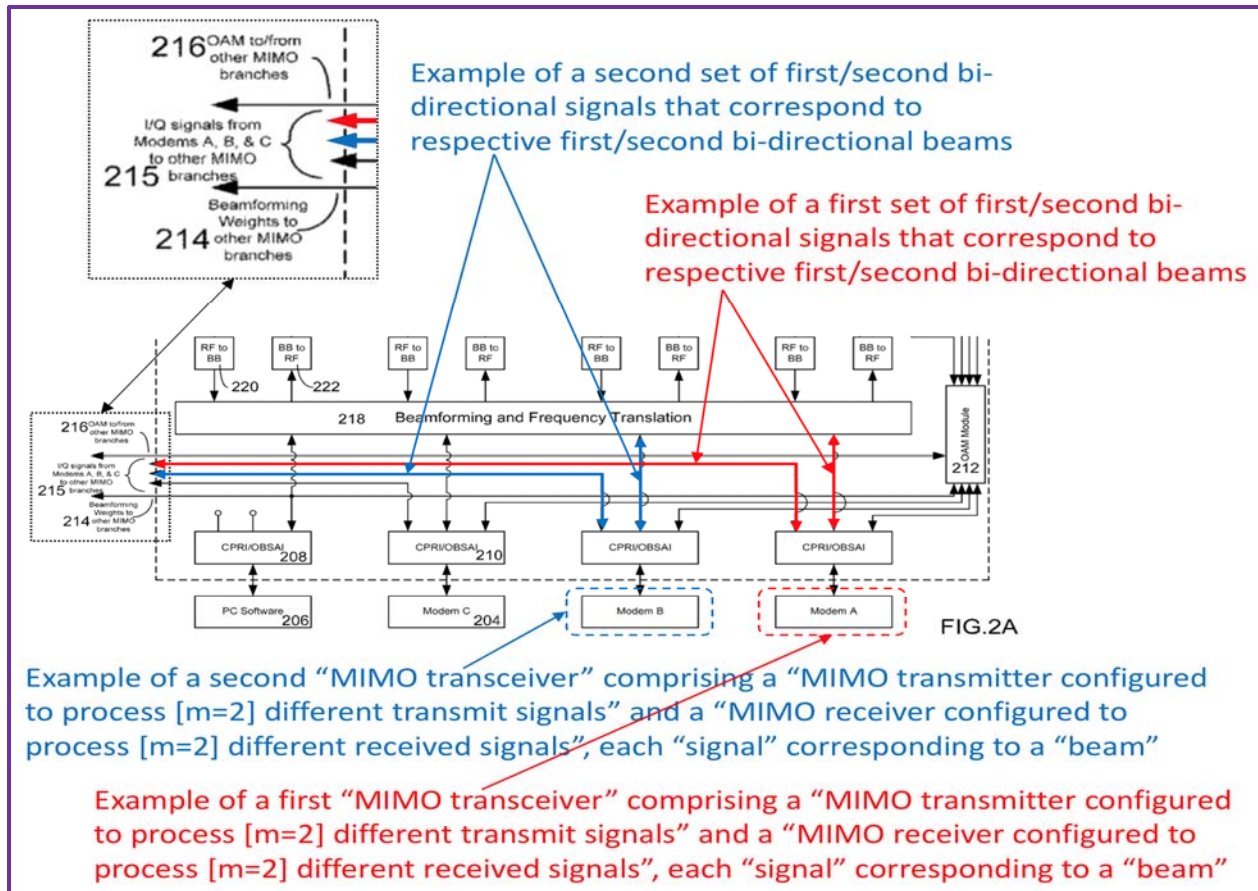
For example, a POSA would understand that “MIMO transceiver” includes a single unit comprising a MIMO transmitter and a MIMO receiver and performs

⁵ Ex-1004, [0002] (“sharing antenna elements and active electronics between multiple operators”); [0048], [0060-0070].

⁶ Ex-1003, ¶¶226-232.

“MIMO” processing. Ex-1003, ¶¶213-215. In other words, a “MIMO transmitter” is “configured to process m different transmit signals.” EX-1001, claim 1. A “MIMO receiver” is “configured to process m different received signals.” Ex-1001, claim 1.

Figure 2A (annotated below) teaches that each of Trigui’s modems include MIMO transmitters/receivers. Figure 2A “represents a single MIMO branch,” and includes “one or more modems” such as the “baseband modules of cellular base stations[.]” Ex-1004, [0036]-[0037]. Trigui states that the “I/Q signals 215 from any of the modems, as well as the beamforming weights 214, can be sent to the other MIMO branches” for transmission. Ex-1004, [0041]; Fig. 2A; Ex-1003, ¶¶219-220. This is shown in the signals leaving Figure 2A to the left (which are highlighted in the annotation).



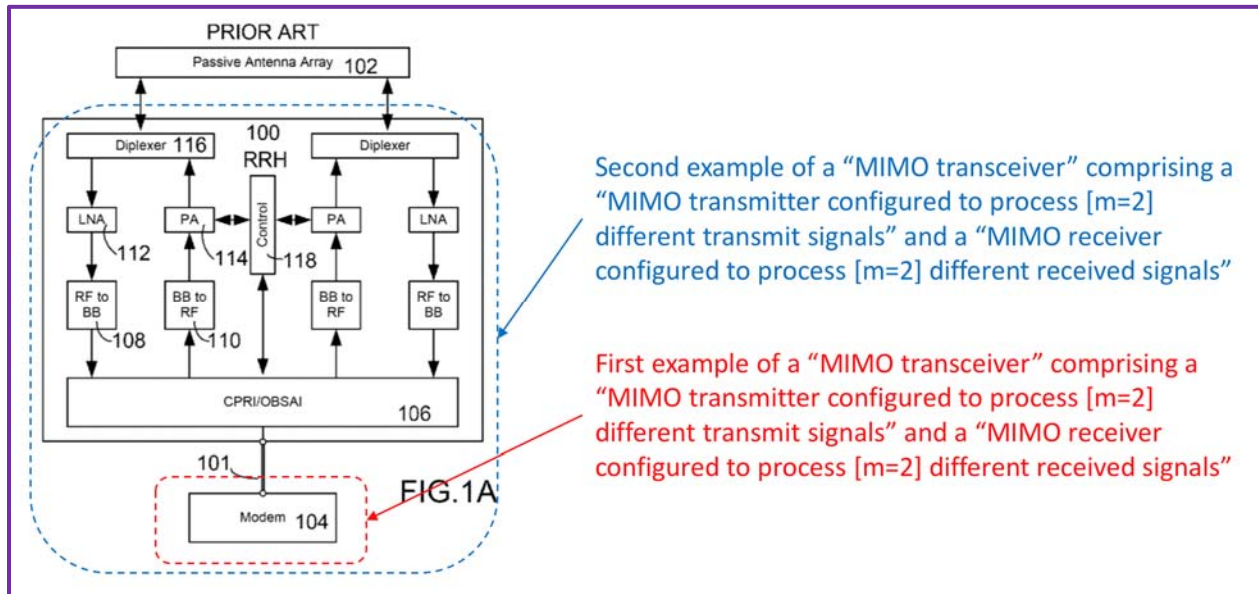
A POSA would thus understand from this disclosure that each modem can be connected to one beam in each array (transmitted/received by one MIMO branch). Each modem converts data signals to I/Q signals 215 and vice versa, *i.e.*, it performs the modulation/demodulation and encoding/decoding functions that the '511 Patent associates with MIMO transceivers. Ex-1003, ¶¶220-221. A POSA would further understand that each modem processes multiple I/Q signals (as shown in the annotated composite of Figure 2 above) and thus processes multiple transmit and receive signals. *Id.* Each of the I/Q signals is being transmitted/received by the modem (*MIMO transceiver*) from a different array (as shown). Thus, each modem

is transmitting/receiving one set of I/Q signals to/from each array. *See also* Ex-1004, [0009] (modem transmits and receives streams along two paths).

A POSA would understand that each modem 204 is a “MIMO transceiver” which includes a “MIMO receiver configured to process *m* different received signals” (the *m* different received signals being the reception paths received from each array) and a “MIMO transmitter configured to process *m* different transmit signals,” (the *m* different transmit signals being the transmission paths). Ex-1003, ¶221.

Moreover, if PO argues that a “MIMO transceiver” must perform more than modulation/demodulation, Figure 1A, annotated below by Dr. Negus, shows a “MIMO transceiver” with any additional functionality that PO may assert is required. Figure 1A shows a prior art implementation for a “2x2 MIMO system” with a “pair of transmission/reception paths,” where a single modem is connected to a “radio remote head” (“RRH”), which is connected to a passive antenna array for transmitting/receiving RF signals. Ex-1004, [0005]-[0009]. The RRH has circuits for converting baseband signals to RF for transmission and converting RF signals to baseband for reception, a power amplifier for transmission, and a low noise amplifier for reception. *Id.* If PO asserts that the “MIMO transceiver” must include additional radio components, then Dr. Negus has explained below that Trigui discloses such a configuration. Under that (potential) PO theory, Trigui discloses the claimed

“MIMO transceiver” using the components highlighted in blue below. Ex-1003, ¶¶217-218.⁷



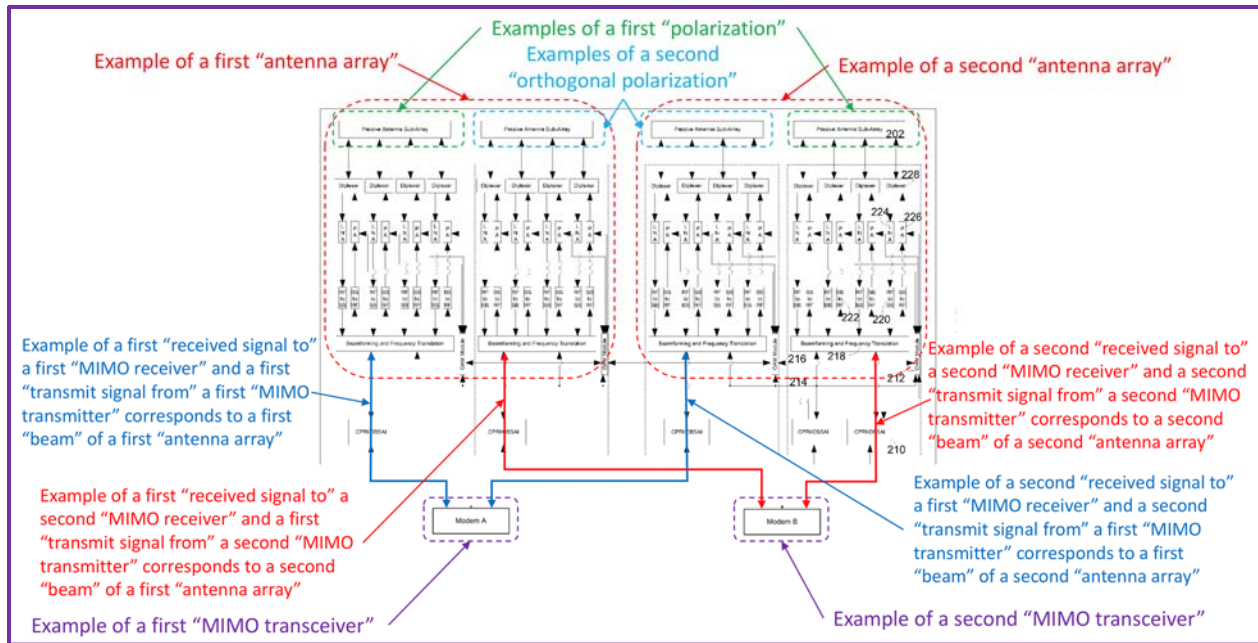
(b) “n” MIMO transceivers

As noted above and for element [1a], in Trigui’s invalidating disclosure, “n”=2, which corresponds to the two beams generated by each of the arrays. Trigui teaches a configuration (as detailed below) in which two “wireless operators” would each have their own modem (2 *MIMO transceivers*). The individual modems would each connect to one beam from each of two antenna arrays (as detailed below).

Trigui teaches that “each MIMO transceiver branch has one beam for transmit and receive.” EX-1004, [0077]. A POSA would understand from Figure 2A and its accompanying discussion (as well as the discussion in [1a]) that Trigui discloses a DIAA system that has multiple MIMO branches. Ex-1004, [0036].

⁷ Trigui uses the term “transceiver” (by itself) to refer to an RF transceiver.

Trigui also teaches that its system can have multiple modems (*e.g.*, Modem A and B from Figure 2A). Each modem has a pair of bi-directional I/Q signals that correspond to a pair of transmission/reception paths for a 2x2 MIMO system and is thus a MIMO transceiver as explained above. Ex-1003, ¶¶220-221. Trigui teaches multiple modems with each modem corresponding to a different network operator. For example, Trigui discloses “multiple operator sharing of a passive antenna, transceivers, and the total available power of the DIAA” with “flexible” “splitting resources between the multiple operators” which is done “on the basis of the individual operator needs.” Ex-1004, [0048]. A POSA understands that Trigui’s usage of the term “operator,” refers to a cellular service provider. Ex-1004, [0060] (the operators “could operate different radio access technologies (RAT) in the case the operators coexist within the frequency bandwidth”) [0068]-[0070]; Ex-1013.000003 (recognizing that “Cellular or wireless telephone towers typically are stand-alone facilities shared by multiple service providers that serve as access points for communicating with subscribers’ handheld and mobile cellular devices”), .000010 (“operators” include well known service providers including “Verizon, AT&T, Sprint, and CellularOne”); Ex-1003, ¶¶96. Indeed, multiple operators sharing an antenna array was known long before the ’511 Patent. Ex-1014, [0026] (disclosing antenna arrays shared by multiple service providers in 2003); Ex-1015, [0002]-[0004] (same); Ex-1016, 2:40-45; Ex-1003, ¶96. This arrangement is depicted in Dr. Negus’s annotated version of Figure 10 below. Ex-1003, ¶251.



Ex-1004, Fig. 10; Ex-1003, ¶¶251-253.

In this context, Trigui teaches a system in which:

- Two operators share the DIAA antenna arrays to share the “passive antenna, transceivers, and total power of the DIAA.” Ex-1004, [0060-0063].
- Each operator may broadcast signals on different RF carriers in MIMO mode. Ex-1004, [0060].

In such a system, a POSA would thus understand that the Figure 10 implementation using the two operator scenario described above, that the “one or more modems 204” would be implemented as two independent modems with one modem for each operator (*i.e.*, ““n multiple-input multiple-output transceivers (MIMO)” where “n=2”), where each modem would process a pair of bi-directional I/Q signals corresponding to a pair of transmission/reception paths for the 2x2 MIMO system

shown in Figure 2A above for the following reasons. Ex-1004, [0037]; Ex-1003, ¶¶223-226.

First, Trigui discloses that the 4xN MIMO DIAAs are multiples of the hardware in Figure 2A and, as Dr. Negus explains, a POSA would understand that the hardware for Figure 2A discloses two independent modems, each processing a pair of bi-directional I/Q signals corresponding to a pair of transmission/reception paths for a 2x2 MIMO system. Ex-1003, ¶¶226-227.

Second, in a two-operator system that is sharing the passive antennas, transceivers, and the total power of the DIAA, a POSA would understand that the network traffic through the DIAA system for operator 1 to its respective subscriber stations is unrelated to the network traffic for operator 2 to its respective subscriber stations. *Id.*, ¶228. Common sense would thus suggest that each operator would have its own modem to process its own network traffic including to ensure that each carrier can independently control its bandwidth through its modem. *Id.*

Third, because the two operators are sharing the resources of the DIAA, the only possible way that two independent modems would be deployed with operator 1 and operator 2 being in MIMO mode is that each modem would process its own pair of “transmission/reception paths” among the four available transmission/reception paths (because MIMO mode requires multiple transmission/reception paths). *Id.*, ¶229.

Fourth, Trigui further discloses that operators 1 and 2 use different RF carriers, which a POSA would understand provides separability for the transmission/reception paths without requiring a single modem to process all available transmission paths (the different RF carriers). Ex-1003, ¶230.

Fifth, Trigui further discloses that operators 1 and 2 can use “different radio access technologies,” which a POSA would understand to add more complexity to use a single modem that processes all transmission/reception paths thus leading a POSA to understand that separate modems would be implemented. Ex-1003, ¶231.

Sixth, Trigui discloses that “modems” are implemented as “baseband modules of cellular base stations” and so a POSA would have a high expectation of success in using two simpler independent modems, each processing a pair of bi-directional “I/Q signals” corresponding to a “pair of transmission/reception paths”. Ex-1003, ¶232.

Thus, Trigui in view of the knowledge of a POSA teaches “n multiple input multiple-output transceivers (MIMO),” such as when using two independent modems for each of a two operator system using Trigui’s Figure 10 as annotated above. Ex-1003, ¶¶226-232.

ii. The “interconnection” limitations

Trigui teaches the “interconnection” limitations that require specific connections between MIMO transceivers and arrays and a relationship between MIMO transceivers and beams. As detailed below, Trigui teaches that each of the

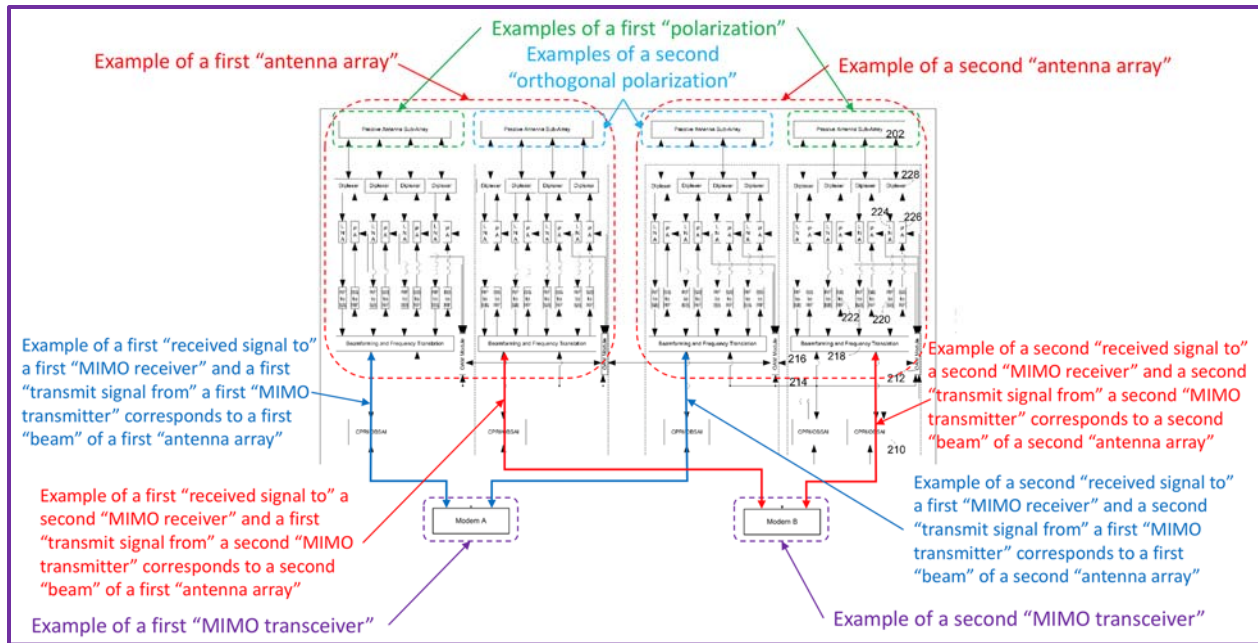
two modems (*MIMO transceiver*) would be connected to one of the two beams from each of the two arrays. This teaches the “interconnections” recited in the claim elements.

As discussed above for [1a], Trigui discloses that Figure 10 teaches a configuration with two arrays, each with two sub-arrays. Each sub-array generates a different beam. Each beam transmits a MIMO branch.

Moreover, as discussed above, Trigui teaches that two operators may have separate modems that share the DIAA arrays (*e.g.*, the two arrays in Figure 10 with their two sub-arrays). Thus, as Dr. Negus explains, in the scenario there would be only two possible ways to interconnect the two arrays in Figure 10 with the two disclosed independent “modems” for the two-operator system where the operators share the passive antenna, transceivers, and total power of the DIAA. Ex-1003, ¶235.

The first possible way is the “direct” connect approach. Each modem connects with only a single one of the two arrays. Each modem uses both transmit/receive paths from a single array. Ex-1003, ¶236.

The second possible way to connect the antenna arrays with the modems is that the antenna arrays are “cross” connected to the two “transmission/reception paths” for each modem, *i.e.*, one to each array. Ex-1003, ¶237. This is shown in annotated Fig. 10 below.



Ex-1003, ¶251. Here, the first transmission/reception path for the first modem connects to one of the bi-directional signals corresponding to one of the beams for one array, while the second transmission/reception path for the first modem connects to one of the bi-directional signals corresponding to one of the bi-directional beams for the other array. Similarly, the first and second transmission/reception paths for the second modem connect to bi-directional signals for the two different arrays. Ex-1003, ¶¶252-253.

Because there are only two possible choices (either “direct” connect or “cross” connect), selecting one of the two options would be an obvious design choice. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

Moreover, in this situation, a POSA would be motivated to select the second way, the “cross” connect approach, for at least the following reasons.

First, in the “direct” connect approach, the operators are not “sharing” of the DIAA components as Trigui repeatedly states is a goal. Ex-1004, [0002] (Trigui’s invention “enabl[e]s a versatile solution for sharing antenna elements and active electronics between multiple operators”), [0062-0063], [0072], [0079]. In the direct connect approach, each particular operator’s modem uses only a single array – effectively devoting each entire array to a particular one of the operators as though the operator implemented its own private array. Such an arrangement does not take full advantage of Trigui’s teaching to share the antenna arrays of the DIAA.

Second, a POSA would have known from the prior art that “correlation of the signals at different antenna elements can significantly reduce the capacity of a MIMO system,” and this “correlation is influenced by the angular spectrum of the channel as well as well as the arrangement and spacing of the antenna elements.” Ex-1006, pp. 473-74. A “cross” connect approach minimizes the “correlation of the signals” among the two “transmission/reception paths” for each modem in the “4xN MIMO DIAAs” when applied to the two operator system of Trigui, and would thus provide the best performance for the “MIMO system” for each operator. Ex-1003, ¶¶239-240.

Third, a POSA would be aware that “it is well known that signals transmitted into a multipath environment from orthogonally polarized antennas (regardless of the respective distances between the orthogonally polarized antennas) are uncorrelated to each other.” Ex-1005, 5:8-17. A “cross” connect approach

minimizes the correlation of the signals among the respective “transmission/reception paths” for each modem in the arrays when applied to the two operator system of Trigui, because it would involve connecting one path for each modem to a “MIMO branch” that has an antenna sub-array of a first polarization while also connecting the other path for that modem to a different MIMO branch that has an antenna sub-array of a second orthogonal polarization. Ex-1003, ¶¶241-242.

Fourth, a POSA would have recognized that two “groups of antennas” can better perform MIMO operations with improved capacity if the “second group” is “positioned with respect to the first group” such that “signals from any antenna in the second group [are] uncorrelated with any signals from any antenna in the first group.” Ex-1005, 8:3-6, 8:12-15. A POSA would also know that as spacing between antennas increases, the correlation between signals being received by the antennas decreases. *Id.*, 2:36-45. To “achieve de-correlation between signals from the different groups,” the two groups of antennas are located at a distance or placed at an antenna spacing that is a significant multiple of the wavelength at which the groups of antennas operate. Ex-1005, 8:6-10, 8:17-20; Ex-1006, pp. 252-253, 474; Ex-1003, ¶243. A POSA would understand that a “cross” connect approach minimizes the correlation of the signals among the respective “transmission/reception paths” for each modem when applied to the two operator system of Trigui, because it would involve connecting one path of each modem to a

MIMO branch that is maximally separated from the MIMO branch connected to the other path from that modem. Ex-1003, ¶244.

Fifth, a POSA would be aware that for base stations in cellular systems, “interacting objects” are “typically concentrated around the [mobile station]” and so the “antenna spacing required to obtain sufficient decorrelation increases” such that the “antenna spacing has to be on the order of 2-20 wavelengths for angular spreads between 1° and 5° in order to achieve decorrelation.” Ex-1006, pp. 252-253. A POSA would have known that, for the “four sub-arrays side-by-side” configuration in Figures 7-11 that, when the modems are “direct” connected to the two depicted antenna arrays, each pair of sub-arrays in this side-by-side configuration would need to have an additional physical separation on the order of 2-20 wavelengths. Ex-1003, ¶¶245-246.

In implementations using a 700 MHz RF carrier, which was commonly used for 3GPP LTE in the United States at the time of the alleged invention, a POSA would have known the corresponding wavelength would have been approximately 17 inches. Ex-1010.000013 (stating that 700 MHz spectrum had advantages including “enormously better range and the same power of signal” than higher frequencies); Ex-1003, ¶247. A POSA would understand that this “direct” connect approach, for the four arrays side-by-side configuration, would increase the physical size of a base station by at least two feet (if not much more) when compared to the cross-connect approach. Ex-1003, ¶248. This additional width would be highly

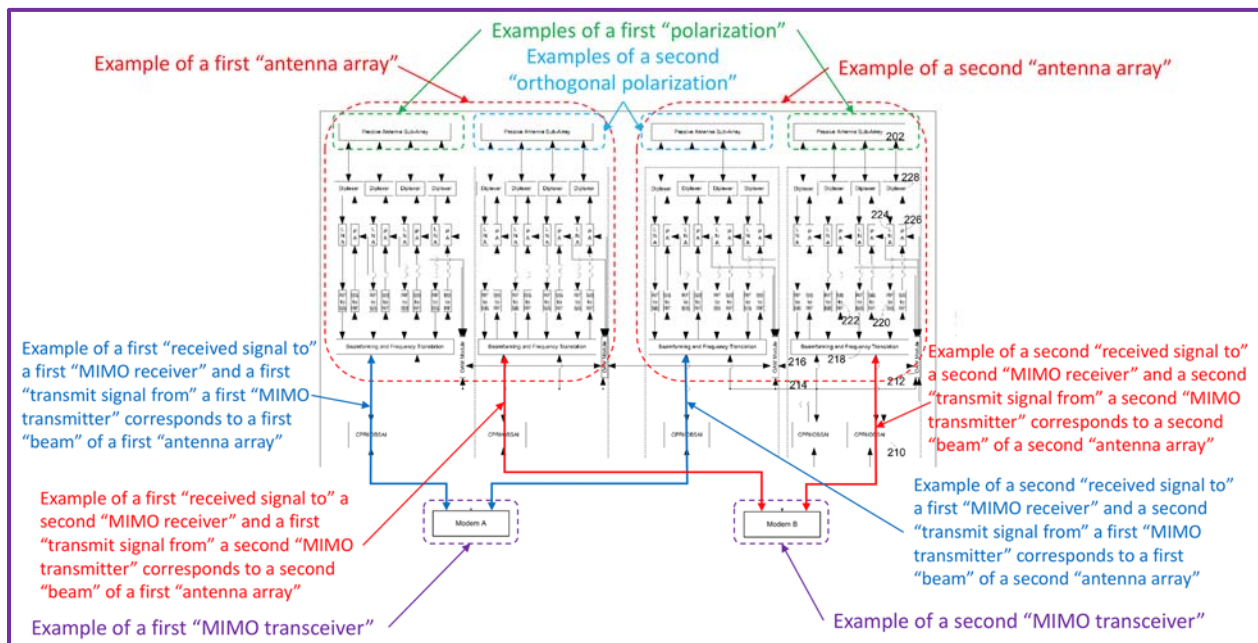
undesirable from an economic standpoint, Ex-1012, a practical mounting consideration on cell station towers, *id.*, and a reliability concern for wind loading. Ex-1011, p. 3 (recognizing that wind loading is directly proportional to cross sectional area); Ex-1003, ¶248.

Sixth and in view of the above, a POSA would have known that for the 4xN MIMO DIAAs in Figures 7-11, when implemented by having the four sub-arrays side-by-side, the maximal separation requirement for MIMO performance is met by: (1) having a first modem corresponding to operator 1 connect its respective paths to the left most MIMO branch (and its corresponding sub-array) and the second from the right MIMO branch (and its corresponding sub-array), and (2) having a second modem corresponding to operator 2 connect its respective paths to the right most MIMO branch (and its corresponding sub-array) and the second from the left MIMO branch (and its corresponding sub-array). Ex-1003, ¶249.

Seventh and in view of the above, a POSA would also have known that to meet the orthogonal polarization criteria for MIMO performance, in the 4xN MIMO DIAAs of Figures 7-11 with four sub-arrays side by side discussed above, the left most MIMO branch and its corresponding antenna sub-array must be of a first polarization and the second from the right MIMO branch and its corresponding antenna subarray must be of a second orthogonal polarization. Ex-1003, ¶250. Similarly, the right most MIMO branch and its corresponding antenna sub-array must be of a first polarization and the second from the left MIMO branch and its

corresponding antenna subarray must be of a second orthogonal polarization. *Id.* This is consistent with Trigui’s disclosures of using “sub-arrays side-by-side but with alternate polarization” and using “two different passive antenna sub-arrays” among “the two DIAAs” in the 4xN MIMO DIAAs implementation. *Id.*

Thus, it would be obvious to a POSA to adopt the “cross” connect approach for interconnecting the two “independent 2xN MIMO DIAAs” with two independent modems in the two operator system of Trigui, as shown in the version of Figure 10 annotated by Dr. Negus below:



Ex-1003, ¶251.

A POSA would thus understand that, as shown in the annotated figure above, it would be obvious that a first reception path to “modem A” for Operator 1 (“an i-th received signal to a j-th MIMO receiver” where “i=1” and “j=1”) connects with a first receive direction beam pattern for the leftmost independent 2xN MIMO DIAA

(it “corresponds to a j-th beam of an i-th antenna array” where “i=1” and “j=1”), and that a second reception path to modem A for Operator 1 (“an i-th received signal to a j-th MIMO receiver” where “i=2” and “j=1”) connects with a first receive direction beam pattern for the right-most independent 2xN MIMO DIAA (it “corresponds to a j-th beam of an i-th antenna array” where “i=2” and “j=1”). Ex-1003, ¶252. Similarly, a first reception path to modem B for Operator 2 (“an i-th received signal to a j-th MIMO receiver” where “i=1” and “j=2”) connects with a first receive direction beam pattern for the leftmost independent 2xN MIMO DIAA (it “corresponds to a j-th beam of an i-th antenna array” where “i=1” and “j=2”), and that a second reception path to modem B for Operator 2 (“an i-th received signal to a j-th MIMO receiver” where “i=2” and “j=2”) connects with a first receive direction beam pattern for the right-most independent 2xN MIMO DIAA (it “corresponds to a j-th beam of an i-th antenna array” where “i=2” and “j=2”). *Id.*

Further, a POSA would also understand that as shown in the annotated figure above, it would be obvious that a first transmission path to modem A for Operator 1 (“an i-th received signal to a j-th MIMO receiver” where “i=1” and “j=1”) connects with a first transmit direction beam pattern for the leftmost independent 2xN MIMO DIAA (it “corresponds to a j-th beam of an i-th antenna array” where “i=1” and “j=1”), and that a second transmission path to modem A for Operator 1 (“an i-th received signal to a j-th MIMO receiver” where “i=2” and “j=1”) connects with a first transmit direction beam pattern for the right-most independent 2xN MIMO

DIAA (it “corresponds to a j -th beam of an i -th antenna array” where “ $i=2$ ” and “ $j=1$ ”). Ex-1003, ¶253. Similarly, a first transmission path to modem B for Operator 2 (“an i -th received signal to a j -th MIMO receiver” where “ $i=1$ ” and “ $j=2$ ”) connects with a first transmit direction beam pattern for the leftmost independent $2 \times N$ MIMO DIAA (it “corresponds to a j -th beam of an i -th antenna array” where “ $i=1$ ” and “ $j=2$ ”), and that a second transmission path to modem B for Operator 2 (“an i -th received signal to a j -th MIMO receiver” where “ $i=2$ ” and “ $j=2$ ”) connects with a first transmit direction beam pattern for the right-most independent $2 \times N$ MIMO DIAA (it “corresponds to a j -th beam of an i -th antenna array” where “ $i=2$ ” and “ $j=2$ ”). *Id.*

Thus, a Trigui in view of the knowledge of a POSA teaches “ n multiple-input multiple-output transceivers (MIMO)” (such as the two independent modems of a two operator system for the exemplary Figure 10 system). Ex-1003, ¶254.

[1c] wherein m , n , v , and z are integer number values,

wherein $i=1, \dots, m$, $j=1, \dots, n$, and $v=1, \dots, m$,

wherein $n \geq 2$ and $m \geq 2$,

wherein $z=1, \dots, w$, and

wherein $n \geq w \geq 2$.

Trigui discloses this limitation. Ex-1003, ¶¶270-271.

As discussed in [1a] and [1b], Trigui’s implementation of two independent $2 \times N$ MIMO DIAAs with two independent modems in a two operator system

discloses “m=2,” “n=2,” “i=1,2,” “j=1,2,” “v=1,2,” “z=1,2,” and “w=2.” Ex-1003, ¶270.

- b. Claim 2 - The system of claim 1, configured to substantially comply with one or more of Electrical and Electronic Engineers (IEEE) 802.11a/b/g/n/ac (WiFi), IEEE 802.16 (WiMAX), 2nd Generation Partnership Project (3GPP) Long Term Evolution (LTE), 3GPP LTE-Advanced, 3GPP LTE-TDD, 3GPP LTE-FDD, High Speed Packet Access (HSPA), and HSPA+.

Trigui discloses this limitation. Trigui recommends “adopting the most spectrally efficient air interface (for example, orthogonal frequency-division multiplexing (OFDM)), and multiple input multiple output (MIMO) antenna techniques by an advanced wireless system such as WiMAX or 3rd Generation Partnership Project Long Term Evolution (3GPP LTE)” (Ex-1004, [0004]). In other words, Trigui’s digitally integrated antenna array for enhancing coverage and capacity of a wireless network is described as being for use in cellular networks, such as those that are compliant with the WiMAX and 3GPP LTE standards in effect as of 2011. Trigui further explains that “the DIAA is designed to comply with mobile WiMAX (IEEE802.16e), UMTS, and LTE base stations supporting space time transmit diversity (‘STTD’) and spatial multiplexing (‘SM’).” Ex-1004, [0074]; Ex-1003, ¶¶274-275.

A POSA would thus consider it obvious that Trigui’s base stations using the two independent 2xN MIMO DIAAs with two independent modems (discussed in claim 1) would be designed to comply with at least one or more of IEEE 802.16

(WiMAX) or 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) that existed as of the time the '511 Patent was filed. Ex-1003, ¶¶276-277.

- c. Claim 4 - The system of claim 1, wherein the m antenna arrays are separated by a distance more than one wavelength apart at the carrier frequency.

Trigui teaches this limitation in view of the knowledge of a POSA. As discussed above in claim 1, a POSA would have been aware that “correlation of the signals at different antenna elements can significantly reduce the capacity of a MIMO system,” and this “correlation is influenced by the angular spectrum of the channel as well as well as the arrangement and spacing of the antenna elements.” Ex-1006, pp. 473-74. Further, a POSA would have known that, for “spatial diversity,” “irrespective of the processing method, performance is influenced by correlation of the signals between the antenna elements,” and that the impact “is different for [base station] antennas and [mobile station] antennas.” Ex-1006, p. 252. For base stations, the “antenna spacing has to be on the order of 2–20 wavelengths for angular spreads between 1° and 5° in order to achieve decorrelation.” Ex-1006, pp. 252-253; Ex-1003, ¶¶281-282.

A POSA would also have known that, when “groups” of antennas are used for MIMO signal processing, the “second group” is “positioned with respect to the first group” such that “signals from any antenna in the second group [are] uncorrelated with signals from any antenna in the first group” when “the second group of antennas is preferably located a distance of at least 10λ from the first group.” Ex-1005, 8:3-

20; Ex-1003, ¶283. Here, λ is the corresponding wavelength of the signal to be transmitted. Ex-1005, 4:30-41.

Thus, a POSA would consider it obvious that, in Trigui's implementation of 2xN MIMO DIAAs with two independent modems, that each 2xN MIMO DIAA (i.e., the "antenna array") would have a spacing "on the order of 2-20 wavelengths" such as a distance of at least 10λ . Ex-1003, ¶284.

- d. Claim 5 - The system of claim 1, wherein the antenna elements are less than or equal to one half wavelength apart at the carrier frequency.

Trigui teaches this limitation. Trigui explains that "antenna arrays may consist of sub-arrays where the antenna elements of each sub-array are combined passively to achieve a predefined pattern" and that "the antenna array elements are closely spaced to avoid grating lobes when steering a beam off boresight direction." Ex-1004, [0050]; Ex-1003, ¶293.

A POSA would have known that "array antennas are often used for [base station] antennas" because "they result in an antenna pattern that can be more easily shaped." Ex-1006, p. 175. For a given antenna array, " d_a is the distance between the antenna elements" and this "distance is usually chosen as $d_a = \lambda/2$ " because " $d_a \leq \lambda/2$ is necessary to avoid spatial aliasing – i.e., periodicities in the antenna pattern" where λ is the wavelength. Ex-1006, pp. 38, 175; Ex-1003, ¶294.

A POSA would thus understand that Trigui's teachings that "antenna array elements are closely spaced to avoid grating lobes" means that the "antenna array

elements” would be spaced with a separation distance of “ $d_a \leq \lambda/2$ ” to avoid grating lobes (or spatial aliasing), meaning that the antenna array elements would be spaced “less than or equal to one half wavelength apart at the carrier frequency.” Ex-1003, ¶¶295-296.

e. Claim 6 - The system of claim 1, wherein the beamformer is an electronic beamformer.

Trigui teaches this limitation. Trigui discloses a DIAA that “share[s] antenna elements and active electronics between multiple operators servicing the same geographic area.” Ex-1004, [0002]. “Server based software” “calculates the ideal beamforming weights 214 that best approximate the desired radiation pattern” and passes them to the DIAA. Ex-1004, [0038]. Each of the modem signals “is multiplied by the beamforming and calibration weights such that when applied to the passive antenna array 202, a user-specified radiation pattern is formed.” Ex-1004, [0045]; Ex-1003, ¶¶303-304.

Trigui also discloses that, in its “beamforming core 218, each branch of the modem signal is multiplied by a complex-valued number such that when applied to the antenna array, along with the other branches of the modem signal, a specified radiation pattern is formed” where the “transmit and receive beamforming weights for each modem are the same.” Ex-1004, [0052], [0055]. Trigui further explains that, “in the receive direction, signals from the passive antenna array 202 are passed through the diplexer 228 before entering a low-noise amplifier 224” and being “converted from RF to baseband by a circuit 220 before being fed to the

beamforming and frequency translation module 218 where beamforming and calibration weights are applied to the received signals to form modem signals.” Ex-1004, [0046]; Ex-1003, ¶¶305-306.

A POSA would thus understand that Trigui’s DIAA with active electronics includes a beamforming core in which beamforming weights for a desired radiation pattern are applied to the antenna array, for both transmit and receive beamforming, shows that the beamforming core along with other components such as RF to baseband and baseband to RF conversion, would mean that the beamforming core is part of a digital integrated and electronic circuit. Ex-1003, ¶307. A POSA would thus understand that Trigui teaches an electronic beamformer, *i.e.* the beamforming core in each MIMO branch. Ex-1003, ¶¶307-308.

f. Claim 9 - The system of claim 1, wherein the system simultaneously provides MIMO and beamforming.

Trigui teaches this limitation. “FIG. 6 illustrates two MIMO branches.” Ex-1004, [0081]. “Each MIMO transceiver branch has one beam for transmit and receive.” Ex-1004, [0077].

Moreover, Trigui’s “single MIMO branch of a DIAA system,” depicted in Figure 2A, which is one of “multiple MIMO branches” where “I/Q signals 215 from any of the modems, as well as the beamforming weights 214, can be sent to other MIMO branches.” Ex-1004, [0036], [0041], Fig. 2A. Further, “in the beamforming core 218, each branch of the modem signal is multiplied by a complex-valued number such that when applied to the antenna array, along with the other branches

of the modem signal, a specified radiation pattern is formed.” Ex-1004, [0052]. A POSA would thus understand that, in the implementation of Trigui with independent 2xN MIMO DIAAs with two independent modems with the two operator system provides MIMO operation at each modem and beamforming on each sub-array at each MIMO branch for each operator. Ex-1003, ¶¶316-318.

g. Claim 10

[10pre]

Trigui discloses this limitation as detailed in claim 1 and [1pre]. Trigui discloses exemplary embodiments of a 4xN MIMO DIAA system for cellular base stations, and a POSA would understand that this MIMO DIAA system is an apparatus. Ex-1004, [0082], Fig. 7; Ex-1003, ¶¶327-329.

[10a], 10[b], 10[c].

Claims [10a], [10b], and 10[c] are identical to [1a], [1b], [1c], respectively and so Trigui teaches it for the same reasons as in [1a]. Ex-1003, ¶¶332-334, ¶¶336-338, ¶¶340-342.

h. Claim 11

Claim 11 is identical to 2 and so Trigui teaches it for the same reasons as in 2. Ex-1003, ¶¶344-346.

i. Claim 13

Claim 13 is identical to 4 and so Trigui teaches it for the same reasons as in 4. Ex-1003, ¶¶348-350.

j. Claim 14

Claim 14 is identical to 5 and so Trigui teaches it for the same reasons as in 5. Ex-1003, ¶¶352-355.

k. Claim 15

Claim 15 is identical to 6 and so Trigui teaches it for the same reasons as in 6. Ex-1003, ¶¶357-359.

l. Claim 18

Claim 18 is identical to 9 and so Trigui teaches it for the same reasons as in 9. Ex-1003, ¶¶361-363.

m. Claim 19

[19pre]

Trigui discloses this limitation. Trigui discloses exemplary embodiments of a 4xN MIMO DIAA system for cellular base stations, and a POSA would understand that this MIMO DIAA system is an apparatus. Ex-1004, [0082], Fig. 7; Ex-1003, ¶¶367-370.

[19a]

Claim [19a] contains limitations that are a subset of claim [1a] because [19a] does not require that the “m antenna arrays” also be “configured to transmit a propagating radio frequency signal” or that the “beamformer” be “configured to produce n different bi-directional beams” as opposed to “configured to produce n different receive beams.” Thus, Trigui teaches[19a] for the reasons set forth in [1a]. Ex-1003, ¶¶372-374.

[19b]

Claim [19b] contains limitations that are a subset of claim [1b] because [19b] does not require “n multiple-input multi-output transceivers (MIMO)” as opposed to only “n multiple-input multi-output receivers (MIMO)” and further does not require that “each MIMO transceiver” also comprise “a MIMO transmitter configured to process m different transmit signals.” Thus, Trigui teaches [19b] for the reasons set forth in [1b]. Ex-1003, ¶¶376-378.

[19c]

Claim [19c] contains limitations that are a subset of claim [1c] because [19c] does not require “v and z are integer number values” where “v=1,...,m”, that “z=1,...,w”, or that “ $n \geq w \geq 2$.” Thus, Trigui teaches [19c] for the reasons set forth in [1c].” Ex-1003, ¶¶380-382.

n. Claim 20

[20pre]

Trigui discloses this limitation. Trigui discloses exemplary embodiments of a 4xN MIMO DIAA system for cellular base stations, and a POSA would understand that this MIMO DIAA system is an apparatus. Ex-1004, [0082], Fig. 7; Ex-1003, ¶¶386-389.

[20a]

Claim [20a] contains limitations that are a subset of claim [1a] because [20a] does not require that the “m antenna arrays” also be “configured to receive a propagating radio frequency signal” or that the “beamformer” be “configured to

produce n different bi-directional beams” as opposed to “configured to produce n different transmit beams.” Thus, Trigui teaches [20a] for the reasons set forth in [1a]. Ex-1003, ¶¶391-393.

[20b]

Claim [20b] contains limitations that are a subset of claim [1b] because [20b] does not require “n multiple-input multi-output transceivers (MIMO)” as opposed to only “n multiple-input multi-output transmitters (MIMO)” and further does not require that “each MIMO transceiver” also comprise “a MIMO receiver configured to process m different transmit signals.” Further, while [20b] recites that “a v-th transmit signal from a z-th MIMO transmitter corresponding to a z-th beam of a v-th antenna array is selected for transmission” instead of “a v-th transmit signal from a z-th MIMO transmitter corresponding to a z-th beam of a v-th antenna array,” this additional change in wording does not convey any additional limitations beyond what is discussed for [1b].

Thus, Trigui teaches [20b] for the reasons set forth in [1b]. Ex-1003, ¶¶396-397.

[20c]

Claim [20c] contains limitations that are a subset of claim [1c] because [20c] does not require that “ $i=1,\dots,m$, $j=1,\dots,n$ ”, that “ $z=1,\dots,w$ ” or that “ $n \geq w \geq 2$ ”, but does require that “ $z=1,\dots,n$ ”. However, as discussed for [1c], Trigui and the knowledge of a POSA disclosed “ $w=n=2$ ”, and so the additional limitation of [20c],

“ $z=1,\dots,n$ ” is shown in [1c]. Thus, Trigui teaches [20c] for the reasons set forth in [1c].” Ex-1003, ¶¶399-401.

B. Ground II - Claims 4-6, 9, 13-15, and 18 are Obvious Over Trigui in view of Rudrapatna

In this ground, Rudrapatna provides express disclosure for certain dependent claims largely using language almost verbatim to the claim language. While Trigui teaches these claim elements in light of the knowledge of a POSA as detailed in Ground 1, Rudrapatna’s express disclosure removes any doubt of the invalidity of these elements.

1. Rudrapatna (Ex-1005)

a. Analogous Art

Rudrapatna⁸ generally relates to a “multiple antenna system that can operate in either multiple input multiple output (MIMO) mode, a beam forming/steering mode or a diversity mode.” Ex-1005, 1:7-10. It observes that “wireless communication systems use antennas to convey (*i.e.*, transmit and receive) communication signals” and that a “plurality of antennas, commonly referred to as an antenna array, is often used to increase the amount of information (e.g., information transfer rate or throughput) that is being conveyed or to improve the

⁸ During prosecution of the ’511 Patent, the Examiner relied on U.S. Patent Publication No. 2002/0132600 (Ex-1007), which is the publication of the patent application that led to the version of Rudrapatna relied on in this Petition. Ex-1005, (65).

quality of a signal being transmitted (or received) by the antenna array” by using a technique called “spatial diversity.” *Id.*, 1:12-21. Rudrapatna explains that “[a] signal transmitted with a spatially diverse structure will have the signal taking different paths to its ultimate destination” but to “improve the quality of a transmitted spatially diverse signal, the transmitted diverse signal can also be processed by a beam forming/steering device” which “controls the relative phase of the signal being transmitted by each antenna in order to form a focused beam in a particular direction in space.” *Id.*, 1:27-40. Rudrapatna further explains that “[a]nother technique used with antenna arrays is called multiple input multiple output (MIMO)” which uses “an antenna array coupled to a signal processing device (including transmission and reception circuitry) to simultaneously transmit and/or receive multiple distinct signals.” *Id.*, 1:51-57. Rudrapatna is thus specifically directed to “an antenna array, which simultaneously performs beam forming/steering, MIMO, diversity operations or any combination thereof.” *Id.*, 3:20-22.

A POSA would thus understand Rudrapatna is from the same field of endeavor as the ’511 Patent and that Rudrapatna is reasonably pertinent to the problem faced by the ’511 Patent. Ex-1003, ¶¶128-136.

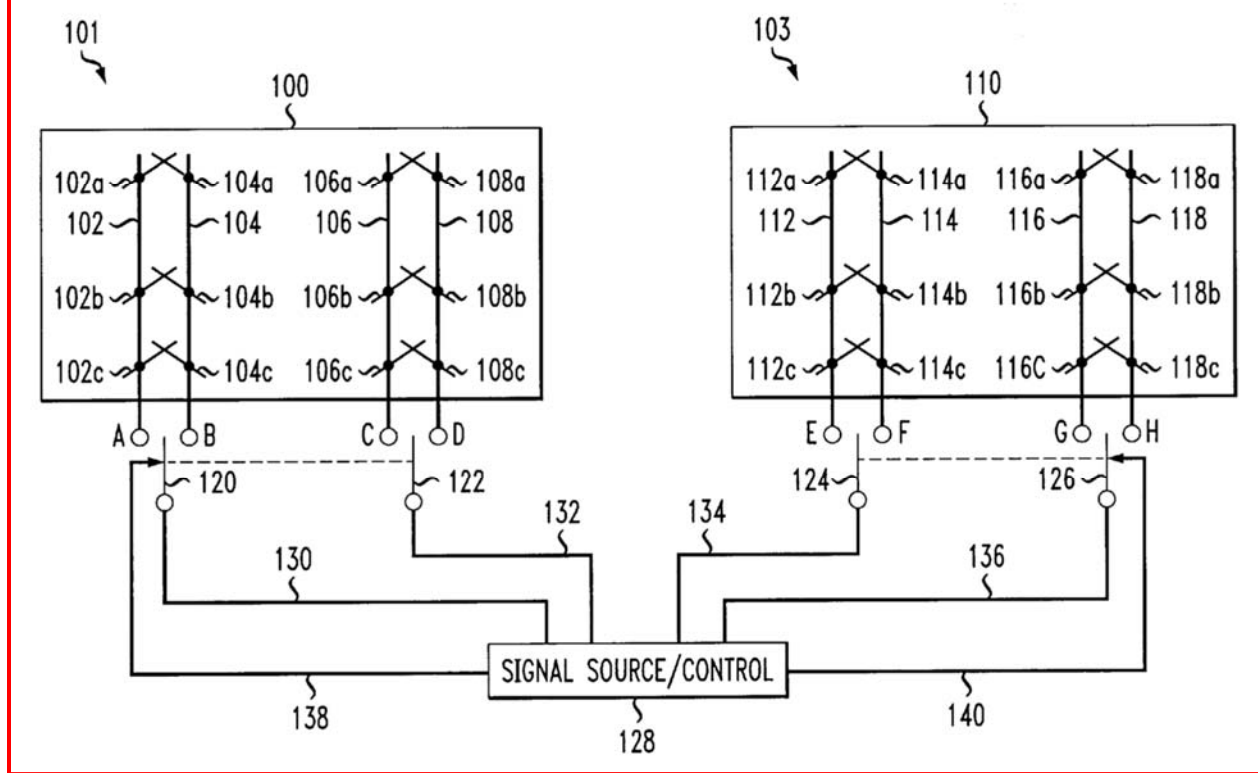
b. Overview of Rudrapatna

Rudrapatna discloses “an antenna array comprising at least two antenna groups where each group comprises at least two pairs of antennas” where “[e]ach

pair of antennas within a group is orthogonally polarized with respect to each other” while “[o]ne antenna from at least one of the pairs in the group is similarly polarized to one antenna from at least one other pair in the group.” Ex-1005, 4:5-14. Further, “[a] first group of antennas is positioned with respect to a second group of antennas such that there is relatively low correlation or no correlation between signals to be transmitted (or being received) by any one of the antennas from different groups.” *Id.*, 4:14-18.

Figure 1 (below) shows “two groups of antennas where each group contains two pairs of antennas.” Ex-1005, 4:49-52. The first group 101 has a first pair of antennas 102, 104 and a second pair of antennas 106, 108. The second group has antenna pairs 112, 114 and 116, 118. *Id.*, 4:63-5:7, 7:65-8:2. Each antenna “has a multiple of antenna elements,” such as antenna 102 having antenna elements 102a, 102b, and 102c in Figure 1. *Id.*

FIG. 1



Each antenna pair in each group has “orthogonally polarized antennas” because “[i]t is well known that signals transmitted into a multipath environment from orthogonally polarized antennas (regardless of the respective distances between the orthogonally polarized antennas) are uncorrelated to each other.” *Id.*, 5:8-17. The antenna array is configured such that “similarly polarized antennas within a group are positioned with respect to each other such that they are able to transmit (or receive) signals which are relatively highly correlated to allow for beam forming/steering operations.” *Id.*, 5:25-30. Further, each group of antennas has switches (such as switches 120, 122, 124, and 126. *Id.*, 5:62-6:4, 8:30-32. These

switches are “operated either electronically, electrically or electromechanically through means well known to those skilled in the art.” *Id.*, 5:62-6:4.

Rudrapatna explains that “[b]eam forming/steering, diversity and/or MIMO operations can be performed in an array where some antennas in certain groups are not activated or where all antennas in certain groups are not activated.” *Id.*, 8:43-48.

2. Motivation to Combine Trigui and Rudrapatna

A POSA would be motivated to combine Trigui and Rudrapatna. Ex-1003, ¶¶258-267. Rudrapatna provides express disclosure of well-known concepts recited in dependent claims 4-6 and 9 (and claims 13-15 and 18, which recite identical elements). The motivations to combine include that both references teach similar systems for combining MIMO systems with beamformed transmissions from multiple arrays. Rudrapatna expressly teaches concepts regarding the physical placement of the arrays and the array elements that a POSA would understand to benefit Trigui’s system by reducing cross-correlation (interference).

For example, Rudrapatna teaches that its second array (group of antennas) is positioned with respect to the first array (group of antennas) such that “signals from any antenna in the second group [are] uncorrelated with any signals from any antenna in the first group” such that “both groups can perform MIMO operations or beam forming/steering operations.” Ex-1005, 8:3-15. Indeed, Rudrapatna states that “the second group of antennas [array] is positioned at a distance of at least 10λ from

the first group [array].” *Id.* A POSA would understand that this matches precisely with the requirements of Trigui’s 4xN MIMO DIAA implementation, discussed above in Ground I to avoid unwanted effects occurring if the antenna arrays are placed too closely together. Ex-1003, ¶¶264-266; §VI.A.2.c.

A POSA would have a reasonable expectation of success because Trigui and Rudrapatna describe the same technology of antenna arrays that provide MIMO and beamforming capabilities. Moreover, for the purposes of the combination below, Rudrapatna is being relied upon for explicitly disclosing information (e.g., distances between antenna arrays and antenna elements) that a POSA already understood in light of Trigui’s disclosure and the knowledge of a POSA.

3. Detailed Application to the Challenged Claims

- a. Claims 4, 13 (“m antenna arrays are separated by a distance more than one wavelength apart at the carrier frequency”)

Trigui in view of Rudrapatna teaches these claims. Rudrapatna expressly teaches that antenna arrays should be separated by more than one wavelength distance.

Rudrapatna describes an antenna array with at least two antenna groups, where each group has two pairs of antennas. Ex-1005, 4:5-10. The first group of antennas “is positioned with respect to [the] second group of antennas such that there is relatively low correlation or no correlation between signals to be transmitted (or being received) by any one of the antennas from different groups.” *Id.*, 4:15-18.

Further, “the second group of antennas is preferably located a distance of at least 10λ from the first group” and “any antenna in the first group is positioned at a distance of at least 10λ from any antenna in the second group.” *Id.*, 8:6-11, 4:35-41 (explaining that λ is the wavelength); Ex-1003, ¶¶283, 288-290, 349, 351. Thus, Rudrapatna expressly discloses this limitation.

Additionally, the additional limitations of claim 4 were present in original claim 6. Ex-1002.000022. The Examiner rejected original claim 6 and stated that Rudrapatna disclosed the additional limitations on two separate occasions. *Id.*, .000070, .000104. The Applicant never disputed that Rudrapatna disclosed the additional limitations of original claim 6. *Id.*, .000081-.000093, .000114-.000127; Ex-1003, ¶280.

- b. Claims 5, 14 (“the antenna elements are less than or equal to one half wavelength apart at the carrier frequency”)

Trigui in view of Rudrapatna teaches these claims. Rudrapatna expressly teaches that antenna elements should be separated by less than one half wavelength distance.

Rudrapatna discloses that the antenna array is “configured such that similarly polarized antennas within a group are positioned with respect to each other such that they are able to transmit (or receive) signals which are relatively highly correlated to allow for beam forming/steering operations” and “the distance separating

similarly polarized antennas is $\lambda/2$ or less. Ex-1005, 5:26-30, 5:35-42, 4:35-41 (explaining that λ is the wavelength); Ex-1003, ¶¶298-300, 353-354, 356.

Thus, Rudrapatna expressly discloses this claim.

c. Claims 6, 15 (“the beamformer is an electronic beamformer”)

Trigui teaches this claim for the reasons discussed in Ground I. §VI.A.2.e; Ex-1003, ¶¶303-308. Rudrapatna provides more express disclosure that the specific beamformer is an “electronic beamformer.”

Additionally, Rudrapatna discloses that each “group of antennas” has “switches” that are “positioned to select either antennas in each of the antenna pairs” and that the “switches are operated either electronically, electrically or electromechanically.” Ex-1005, 5:61-63, 5:66-6:2. A POSA would understand that these switches disclose beamforming and that the switches being operated electronically thus discloses an electronic beamformer. Ex-1003, ¶¶311-313, 358, 360.

Additionally, the additional limitations of claim 6 were present in original claim 8. Ex-1002.000022. The Examiner rejected original claim 8 and stated that Rudrapatna disclosed the additional limitations on two separate occasions. *Id.*, .000071, .000104. The Applicant never disputed that Rudrapatna disclosed the additional limitations of original claim 8. *Id.*, .000081-.000093, .000114-.000127; Ex-1003, ¶¶302, 310.

d. Claims 9, 18 (“simultaneously provides MIMO and beamforming”)

Trigui teaches this claim for the reasons discussed in Ground I. §VI.A.2.e; Ex-1003, ¶¶316-318.

Rudrapatna further discloses that its antenna array “simultaneously performs beam forming/steering, MIMO, diversity operations or any combination thereof.” Ex-1005, 3:20-22; Ex-1003, ¶¶321-323, 362, 364. Trigui and Rudrapatna thus teach this limitation.

Additionally, the additional limitations of claim 9 were present in original claim 11. Ex-1002.000022. The Examiner rejected original claim 11 and stated that Rudrapatna disclosed the additional limitations on two separate occasions. *Id.*, pp. 71, 104. The Applicant never disputed that Rudrapatna disclosed the additional limitations of original claim 11. *Id.*, pp. 81-93, 114-127; Ex-1003, ¶315, 320.

VII. THE BOARD SHOULD NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION

A. The Board Should Not Deny Institution Under 35 U.S.C. § 325

The primary reference (Trigui) was not disclosed to, or considered by, the Examiner and has not been previously evaluated by either the Examiner or the Board against the ‘511 claims. The secondary reference in Ground 2 (Rudrapatna) was considered by the Examiner solely as a secondary reference. For the dependent claims for which Rudrapatna is cited in Ground 2, the applicant did not challenge that Rudrapatna disclosed the dependent claims.

Thus, under these conditions (with the Board never considering either the primary reference in Grounds 1 and 2 or the combination of references in Ground 2), the Board should not deny institution under Section 325.

B. The Board Should Not Deny Institution Under 35 U.S.C. § 314(a)

The Board has discretion to deny institution under 35 U.S.C. § 314(a). In *Apple Inc. v. Fintiv, Inc.*, the Board set forth six non-dispositive factors to guide whether efficiency, fairness, and the merits support the exercise of authority to deny institution in view of an earlier trial date in the parallel proceeding. On June 21, 2022, the Director issued Interim Guidance regarding application of the *Fintiv* factors stating that “the PTAB will not deny institution of an IPR or PGR under *Fintiv* ... when a petition presents compelling evidence of unpatentability.” USPTO Memorandum, Interim Procedure for Discretionary Denials in AIA PostGrant Proceedings with Parallel District Court Litigation (June 21, 2022), at 9. Here, the Petition is particularly strong and presents compelling evidence of unpatentability of the Challenged Claims. Specifically, the Petition explains how the primary reference, Trigui, alone and in combination with the other references, discloses the claimed limitations. The evidence presented, if unrebutted in trial, would plainly lead to a conclusion that one or more claims are unpatentable by a preponderance of the evidence. Thus, under the Interim Guidance, the Board should not deny institution.

Likewise, the Board’s decision in *Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (Dec. 1, 2020) (precedential as to § II.A) instructs that a holistic view of the remaining *Fintiv* factors also weighs in favor of institution.

Factor 1 is neutral because no request for stay has been filed in the District Court Litigation (§VIII.B). *Sand Revolution II LLC v. Continental Intermodal Group – Trucking LLC*, IPR2019-01393, Paper 24 at 7 (June 16, 2020) (informative). Under factor 2, the earliest scheduled trial date has been set for March 3, 2025. Further, a Final Written Decision in this matter is expected in or around November, 2025. Because much can change in four months, the current trial date does not support denial. *Dish Network v. Broadband iTV*, IPR2020-01280, Paper 17 at 16 (PTAB Feb. 4, 2021) (“We cannot ignore the fact that the currently scheduled trial date is more than nine months away and much can change during this time”).

Factor 3 favors institution. The *Markman* hearing is scheduled for September 11, 2024, fact discovery closes on October 4, 2024, and expert discovery closes on November 18, 2024. Thus, the Related Litigation is in its early stages, and the investment in it has been minimal. The district court will not invest significant resources or issue substantive orders related to the challenged patent prior to an institution decision; see *PEAG LLC v. Varta Microbattery GMBH*, IPR2020-01214, Paper 8 at 17 (Jan. 6, 2021) (little investment in the parallel proceeding where claim construction hearing had not yet been held and discovery was not complete).

Under factor 4, Petitioner stipulates that if the IPR is instituted, it will not pursue, in District Court, the same invalidity grounds for the claims challenged here. *Sand Revolution II* at 7. Thus, the grounds presented here will not be asserted in District Court against the challenged claims and this factor weighs in favor of institution. *Sand Revolution II* at 12. Under factor 5, while Petitioner is a defendant in District Court, nothing within *Fintiv* suggests that the same parties between the proceedings weighs in favor of discretionary denial. *See HP Inc. v. Slingshot Printing LLC*, IPR2020-01084, Paper 13 at 9 (Jan. 14, 2021) (“same parties as parallel proceeding” makes factor 5 “neutral”).

Under factor 6, other circumstances weigh in favor of institution. The merits of the Petition are particularly strong. For example, each prior art reference discloses the very limitation by which the '511 Patent gained allowance. EX-1002.000124, .000198-.000206; §IV.B. When viewed holistically, the timing of the present Petition is reasonable; there has been relatively limited investment in the EDTX litigation; and there is minimal overlap between the present IPR and the parallel litigation. Coupling these *Fintiv* considerations with compelling evidence of unpatentability, the efficiency and integrity of the IPR process is best served by instituting review.

VIII. MANDATORY NOTICES UNDER 37 C.F.R. §42.8

A. Real-Party-in-Interest (37 C.F.R. §42.8(b)(1))

The real party-in-interest in this Petition is Ericsson Inc., and corporate parent Telefonaktiebolaget LM Ericsson, and Nokia of America Corporation. No other parties have directed, funded, or controlled the filing of this IPR, and this IPR was not filed at the behest of any other party.

To avoid additional issues associated with real parties in interest, Petitioners likewise identify T-Mobile USA, Inc., AT&T Services Inc., AT&T Mobility LLC, AT&T Corporation, and Cellco Partnership d/b/a Verizon Wireless because Petitioners' products provided to these entities have been accused of infringement in the Related Matters identified below.

B. Related Matters (37 C.F.R. §42.8(b)(2))

As of the filing date of this Petition and to the best knowledge of Petitioners, the '511 Patent is (or was) involved in the following litigations:

- *XR Communications LLC v. Verizon Communications, Inc. et al.*, U.S.D.C. EDTX Case No. 2:23-cv-00203-JRG-RSP;
- *XR Communications LLC v. T-Mobile USA, Inc.*, U.S.D.C. EDTX Case No. 2:23-cv-00204-JRG-RSP;
- *XR Communications LLC v. AT&T SERVICES INC.; AT&T MOBILITY LLC; AND AT&T CORP.*, U.S.D.C. EDTX Case No. 2:23-cv-00202-JRG-RSP.

These are referenced collectively as the “Related Litigation(s).” As of the filing date of this Petition and to the best knowledge of Petitioners, the ’511 Patent has not been subject to any IPR proceedings.

C. Lead/Back-Up Counsel (37 C.F.R. §42.8(b)(3)):

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D. Notice of Service Information (37 C.F.R. §42.8(b)(4)):

Please direct all correspondence to lead and back-up counsel at the above addresses. Petitioners consent to electronic service at the email addresses above.

IX. CONCLUSION

Petitioners request the Board institute IPR and cancel all Challenged Claims.

Respectfully submitted,

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Dated: May 8, 2024

CERTIFICATION OF SERVICE ON PATENT OWNER

Pursuant to 37 C.F.R. §§ 42.6(e), 42.8(b)(4) and 42.105, the undersigned certifies that on the 8th of May, 2024, a complete and entire copy of this Petition for *Inter Partes* Review of U.S. Patent No. 8,737,511 and all supporting exhibits were served via email and/or electronic download by agreement of Patent Owner, to the correspondence address of record for the '511 Patent:

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CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24 *et seq.*, the undersigned certifies that this document complies with the type-volume limitations. This document contains 12,542 words as calculated by the “Word Count” feature of Microsoft Word 2010, the word processing program used to create it. Additionally, the annotations in the Figures in this document contain 954 words, for a total of 13,496 words.

Dated: May 8, 2024

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