PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

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PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)* 14 JUN 2018

Applicant's or agent's file reference
119314-8012.WO01

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US 18/17090	06 February 2018 (06.02.2018)	11 August 2017 (11.08.2017)

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H04B 15/00 (2018.01)
CPC - H04B 10/516; H04B 7/0868; H04W 28/0231

Applicant COHERE TECHNOLOGIES

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	31 May 2018	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Box No. IV Lack of unity of invention

1. ☐ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:

   ☐ paid additional fees.

   ☐ paid additional fees under protest and, where applicable, the protest fee.

   ☐ paid additional fees under protest but the applicable protest fee was not paid.

   ☒ not paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-6, 14, and 15: drawn to a wireless communication method and system for transmitting orthogonal time frequency space (OTFS) modulated wireless signals from a transmitter.

Group II: claims 7-13 and 16-19: drawn to a wireless communication method and system for receiving a signal comprising multiple symbols.

The inventions listed as Groups I and II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special technical features:
Group I requires transmitting orthogonal time frequency space (OTFS) modulated wireless signals from a transmitter, comprising: receiving information bits for transmission, wherein the information bits include user data and control data; segmenting the information bits into a stream of segments; applying a corresponding forward error correction (FEC) code to each of the stream of segments and combining outputs of the FECs to generate a stream of symbols; processing the stream of symbols to generate a waveform; and transmitting the waveform over a communication medium, not found in the other groups.

Group II requires performing channel equalization on the signal to generate a channel equalized signal;
logically dividing the channel equalized signal into a first number of segments; demodulating and symbol de-mapping the channel equalized signal in successive steps such that each step operates to recover one or more bits of one of the number of the segments to generate a demodulated bitstream; wherein an order in which the successive steps are performed depends on a reliability of success of recovering the one or more bits in each of the successive steps; processing the demodulated bitstream to generate information related to the bits from the signal; providing a feedback signal to the channel equalization operation based on the processing of the demodulated bitstream; and logically separating user data and control data from the demodulated bitstream, not found in the other groups.

Shared Features:
The only technical features shared by Groups I and II that would otherwise unify the groups are a wireless signal including information bits that include user data and control data.

However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by US 2016/0095105 A1 to Qualcomm Incorporated (hereinafter 'Qualcomm') 31 March 2016 (31.03.2016), which discloses wireless signal including information bits that include user data and control data (para [0132] -In another example, transmitting the uplink control data at Block 1708 may include transmitting the uplink control data as two or more ACK/NACK bits for each of two or more codewords and/or one or more carriers.).

As the shared technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

Groups I and II therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.

4. Consequently, this opinion has been established in respect of the following parts of the international application:

   ☐ all parts.

   ☒ the parts relating to claims Nos. 1-6, 14, 15

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Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-6, 14, 15	YES
	Claims	None	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-6, 14, 15	NO
Industrial applicability (IA)	Claims	1-6, 14, 15	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-6, 14 and 15 lack an inventive step under PCT Article 33(3) as being obvious over US 2002/0136276 A1 to Franceschini et al. (hereinafter 'Franceschini') in view of US 2008/0165873 A1 to Ghosh et al. (hereainfter 'Ghosh').

Regarding Claim 1, Franceschini discloses a wireless communication method for transmitting orthogonal time frequency space (OTFS) modulated (para [0022]-[0023] "The novel spread spectrum waveform is a type of Orthogonal Frequency Modulation (OFDM) waveform wherein an OFDM waveform is combined with a unique coherent subband coding including Walsh Orthogonal Codes and Reed Solomon forward error correction (FEC) to provide reliable communications. The technique incorporates both transmit and receive frequency excision and Reed Solomon symbol erasures (erasure decisions use side information provided by the Walsh decoder) to provide performance gains in narrow band interference. Frequency division - sequence spectrum spreading (FD-DSS) resembles OFDM, except that the sub-bands are not narrowband fixed channels, but rather, flexible time-frequency channels that allow direct sequence spectrum spreading with large order M-ary coding across both dimensions simultaneously.")

wireless signals from a transmitter (para [0021] "Referring now to FIG. 1, a spread spectrum radio frequency communication system 100 is shown to include a transmitter 110..."), comprising:

receiving information bits for transmission (stream of data, para [0011] "In accordance with the present invention, a method of providing a spread spectrum radio frequency communication signal includes the steps of forming a stream of data into a plurality of data packets and embedding each data packet into a physical layer packet including the steps of adding a packet header, performing a cyclic redundancy check and encoding the data.");

segmenting the information bits into a stream of segments (forming into a plurality of data packets, para [0011] "In accordance with the present invention, a method of providing a spread spectrum radio frequency communication signal includes the steps of forming a stream of data into a plurality of data packets and embedding each data packet into a physical layer packet including the steps of adding a packet header, performing a cyclic redundancy check and encoding the data.");

applying a corresponding forward error correction (FEC) code to each of the stream of segments and combining outputs of the FECs to generate a stream of symbols (para [0011] "The encoding the data step includes the steps of encoding digital data with a Reed Solomon forward error correction algorithm to provide RS symbols and interleaving the RS symbols across a plurality of coherent subbands.");

processing the stream of symbols to generate a waveform (para [0030] "The novel OFDM waveform utilizes a unique approach to multipath mitigation that is optimized for a mobile packet network and does not have the training and convergence problems of other OFDM equalization techniques");

and transmitting the waveform over a communication medium (radio frequency, para [0021] "Referring now to FIG. 1, a spread spectrum radio frequency communication system 100 is shown to include a transmitter 110 and a receiver 120.").

Franceschini does not specifically disclose wherein the information bits include user data and control data.

However, Ghsoh in the related art of orthogonal frequency division multiplexing of data over a communication medium (para [0016]) does disclose wherein the information bits include user data and control data (para [0017] "Generally, an embodiment of the present invention encompasses a method for transmitting uplink control signaling and uplink user data in an OFDM communication system comprising receiving user data non-associated/data associated control signaling, receiving user data, puncturing the user data non-associated/data associated control signaling into the user data stream to produce a data stream wherein the control and user data information are multiplexed, and conveying the punctured data stream to a radio access network via an air interface.").

It would have been obvious to one of ordinary skill in the art to modify the method, as disclosed by Franceschini, so as to include combining both user data and control data, as disclosed by Ghsoh, because this preservers the single carrier property of a single carrier OFDM system and avoids the high peak-to-average power ratio at the UE that results from conveying control signaling in a set of frequencies and time slots different from a set of frequencies and time slots used to convey user data (Ghsoh - para [0041]).

(Continued in Supplemental Boxes)

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Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claim 5 includes the term "the constellation symbol label."
However, this is considered to be in error because the term lacks antecedence.
For the purposes of this search and opinion, the term has been interpreted to mean "a capacitor connected in series".

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
Box V.2 Citations and explanations:

Regarding Claim 2, Franceschini in view of Ghsoh disclose the method of claim 1, Ghsoh further discloses wherein each segment in the stream of segments has an equal bit length (para [0042] "Communication system 100 further provides for either a joint coding or a separate coding of multiple Layer 1 and Layer 2 control fields before the control fields are multiplexed with the user data, and for an insertion of dummy data in any empty control fields. By including dummy data in an empty control field, each codeword is of a same length, which may simplify the multiplexing and de-multiplexing process.").

Regarding Claim 3, Franceschini in view of Ghsoh disclose the method of claim 1. Ghsoh further discloses wherein the processing the stream of symbols includes: transforming the stream of symbols to orthogonal time frequency space (OTFS) domain by performing an OTFS transform on the stream of symbols (para [0022]-[0023] "The novel spread spectrum waveform is a type of Orthogonal Frequency Modulation (OFDM) waveform wherein an OFDM waveform is combined with a unique coherent subband coding including Walsh Orthogonal Codes and Reed Solomon forward error correction (FEC) to provide reliable communications. The technique incorporates both transmit and receive frequency excision and Reed Solomon symbol erasures (erasure decisions use side information provided by the Walsh decoder) to provide performance gains in narrow band interference. Frequency division - sequence spectrum spreading (FD-DSS) resembles OFDM, except that the sub-bands are not narrowband fixed channels, but rather, flexible time-frequency channels that allow direct sequence spectrum spreading with large order M-ary coding across both dimensions simultaneously.").

Regarding Claim 4, Franceschini in view of Ghsoh disclose the method of claim 1. Franceschini further discloses wherein at least some of the FEC codes have different block sizes from each other (para [0049] "As shown in FIG. 3, subband bits are grouped into groups of m=(5,10, 11, or 12) bits. Each group is then mapped into a Walsh codeword of size 2 m chips (32,1024,2048 or 4096).").

Regarding Claim 5 and as per the assumptions of Box No. VIII, Franceschini in view of Ghsoh disclose the method of claim 1. Ghsoh further discloses wherein each stream of segments is applied to one or more of the constellation symbol label (para [0030] "The codeword is then mapped (506) to a constellation of symbols by a symbol mapper 608 to produce a symbol stream that is routed to puncturing/insertion module 406. Symbol mappers, which map multiple bits to a symbol in a constellation of symbols, are well known in the art and will not be described in detail herein.").

Regarding Claim 6, Franceschini in view of Ghsoh disclose the method of claim 1. Franceschini further discloses wherein the combining the outputs of the FECs includes: performing, on an output of each FEC, a corresponding interleaving operation (para [0033] "The RS symbols are then interleaved across the subbands. The interleaving assures that only one RS symbol from any RS block is transmitted within any subband. The second coding process is a subband coding process that encodes the symbols transmitted within each subband. Subband coding is performed with low rate Walsh codes. Thus the RS symbols that have been interleaved within a subband are further encoded with a low rate Walsh orthogonal code."); and combining outputs of the interleaving operations to generate the stream of symbols (para [0038] "Each subband has a corresponding Walsh encoder 214 wherein the interleaved RS signal is Walsh encoded in a known manner. The Walsh encoded RS signal is then encrypted by a transmission security device 216 and fed to subband filter 218. The output of the respective subband filters 218, 218b . . . 218n are fed to an Inverse Fast Fourier Transform (IFFT) 220 wherein the signal is fed to the exciter 20.").

Regarding Claim 14, Franceschini discloses a method for transmitting orthogonal time frequency space (OTFS) modulated (para [0022]-[0023] "The novel spread spectrum waveform is a type of Orthogonal Frequency Modulation (OFDM) waveform wherein an OFDM waveform is combined with a unique coherent subband coding including Walsh Orthogonal Codes and Reed Solomon forward error correction (FEC) to provide reliable communications. The technique incorporates both transmit and receive frequency excision and Reed Solomon symbol erasures (erasure decisions use side information provided by the Walsh decoder) to provide performance gains in narrow band interference. Frequency division - sequence spectrum spreading (FD-DSS) resembles OFDM, except that the sub-bands are not narrowband fixed channels, but rather, flexible time-frequency channels that allow direct sequence spectrum spreading with large order M-ary coding across both dimensions simultaneously.") wireless signals from a transmitter (para [0021] "Referring now to FIG. 1, a spread spectrum radio frequency communication system 100 is shown to include a transmitter 110..."), comprising:

receiving information bits for transmission (stream of data, para [0011] "In accordance with the present invention, a method of providing a spread spectrum radio frequency communication signal includes the steps of forming a stream of data into a plurality of data packets and embedding each data packet into a physical layer packet including the steps of adding a packet header, performing a cyclic redundancy check and encoding the data."),

segmenting the information bits into a stream of segments (forming into a plurality of data packets, para [0011] "In accordance with the present invention, a method of providing a spread spectrum radio frequency communication signal includes the steps of forming a stream of data into a plurality of data packets and embedding each data packet into a physical layer packet including the steps of adding a packet header, performing a cyclic redundancy check and encoding the data.");

applying a corresponding forward error correction (FEC) code to each of the stream of segments and combining outputs of the FECs to generate a stream of symbols (para [0011] "The encoding the data step includes the steps of encoding digital data with a Reed Solomon forward error correction algorithm to provide RS symbols and interleaving the RS symbols across a plurality of coherent subbands.");

processing the stream of symbols to generate a waveform (para [0030] "The novel OFDM waveform utilizes a unique approach to multipath mitigation that is optimized for a mobile packet network and does not have the training and convergence problems of other OFDM equalization techniques");

(Continued on next page)
(Claim 14 continued)

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:
Box V.2 Citations and explanations:
(Claim 14 continued)

and transmitting the waveform over a communication medium (radio frequency, para [0021] "Referring now to FIG. 1, a spread spectrum radio frequency communication system 100 is shown to include a transmitter 110 and a receiver 120.").

Franceschini does not specifically disclose a wireless communication device comprising a processor configured to implement a method; wherein the information bits include user data and control data.

However, Ghsoh in the related art of orthogonal frequency division multiplexing of data over a communication medium (para [0016]) does disclose a wireless communication device comprising a processor configured to implement a method (para [0020] "Each of UE 102, transceiver 132, and controller 140 includes a respective processor 104, 134, 142 such as one or more microprocessors, microcontrollers, digital signal processors (DSPs), combinations thereof or such other devices known to those having ordinary skill in the art. The particular operations/functions of processors 104, 134, and 142 and respectively thus of UE 102, transceiver 134, and controller 140, are determined by an execution of software instructions and routines that are stored in a respective at least one memory device 106, 136, 144 associated with the processor, such as random access memory (RAM), dynamic random access memory (DRAM), and/or read only memory (ROM) or equivalents thereof, that store data and programs that may be executed by the corresponding processor.");

and wherein the information bits include user data and control data (para [0017] "Generally, an embodiment of the present invention encompasses a method for transmitting uplink control signaling and uplink user data in an OFDM communication system comprising receiving user data non-associated/data associated control signaling, receiving user data, puncturing the user data non-associated/data associated control signaling into the user data stream to produce a data stream wherein the control and user data information are multiplexed, and conveying the punctured data stream to a radio access network via an air interface.").

It would have been obvious to one of ordinary skill in the art to modify the method, as disclosed by Franceschini, so as to include a wireless communication device including a processor configured to implement the method and combining both user data and control data, as disclosed by Ghsoh, because being able to implement a method on a wireless communication device increases the number of situations where the method may be used, as well as, combining both user data and control data preserves the single carrier property of a single carrier OFDM system and avoids the high peak-to-average power ratio at the UE that results from conveying control signaling in a set of frequencies and time slots different from a set of frequencies and time slots used to convey user data (Ghsoh - para [0041]).

Regarding Claim 15, Franceschini discloses a method for transmitting orthogonal time frequency space (OTFS) modulated (para [0022]-[0023] "The novel spread spectrum waveform is a type of Orthogonal Frequency Modulation (OFDM) waveform wherein an OFDM waveform is combined with a unique coherent subband coding including Walsh Orthogonal Codes and Reed Solomon forward error correction (FEC) to provide reliable communications. The technique incorporates both transmit and receive frequency excision and Reed Solomon symbol erasures (erasure decisions use side information provided by the Walsh decoder) to provide performance gains in narrow band interference. Frequency division - sequence spectrum spreading (FD-DSS) resembles OFDM, except that the sub-bands are not narrowband fixed channels, but rather, flexible time-frequency channels that allow direct sequence spectrum spreading with large order M-ary coding across both dimensions simultaneously.") wireless signals from a transmitter (para [0021] "Referring now to FIG. 1, a spread spectrum radio frequency communication system 100 is shown to include a transmitter 110..."), comprising:

receiving information bits for transmission (stream of data, para [0011] "In accordance with the present invention, a method of providing a spread spectrum radio frequency communication signal includes the steps of forming a stream of data into a plurality of data packets and embedding each data packet into a physical layer packet including the steps of adding a packet header, performing a cyclic redundancy check and encoding the data.");

segmenting the information bits into a stream of segments (forming into a plurality of data packets, para [0011] "In accordance with the present invention, a method of providing a spread spectrum radio frequency communication signal includes the steps of forming a stream of data into a plurality of data packets and embedding each data packet into a physical layer packet including the steps of adding a packet header, performing a cyclic redundancy check and encoding the data.");

applying a corresponding forward error correction (FEC) code to each of the stream of segments and combining outputs of the FECs to generate a stream of symbols (para [0011] "The encoding the data step includes the steps of encoding digital data with a Reed Solomon forward error correction algorithm to provide RS symbols and interleaving the RS symbols across a plurality of coherent subbands.");

processing the stream of symbols to generate a waveform (para [0030] "The novel OFDM waveform utilizes a unique approach to multipath mitigation that is optimized for a mobile packet network and does not have the training and convergence problems of other OFDM equalization techniques");

and transmitting the waveform over a communication medium (radio frequency, para [0021] "Referring now to FIG. 1, a spread spectrum radio frequency communication system 100 is shown to include a transmitter 110 and a receiver 120.").

Franceschini does not specifically disclose a computer-readable memory storing instruction comprising processor-implementable code, wherein the code include instructions which, when executed by the processor, cause the processor to implement a method; and wherein the information bits include user data and control data.

(Continued on next page)
(Claim 15 continued)

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Supplemental Box

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Continuation of:
Box V.2 Citations and explanations:
(Claim 15 continued)

However, Ghsoh in the related art of orthogonal frequency division multiplexing of data over a communication medium (para [0016]) does disclose a computer-readable memory storing instruction comprising processor-implementable code, wherein the code include instructions which, when executed by the processor, cause the processor to implement a method (para [0020] "Each of UE 102, transceiver 132, and controller 140 includes a respective processor 104, 134, 142 such as one or more microprocessors, microcontrollers, digital signal processors (DSPs), combinations thereof or such other devices known to those having ordinary skill in the art. The particular operations/functions of processors 104, 134, and 142 and respectively thus of UE 102, transceiver 134, and controller 140, are determined by an execution of software instructions and routines that are stored in a respective at least one memory device 106, 136, 144 associated with the processor, such as random access memory (RAM), dynamic random access memory (DRAM), and/or read only memory (ROM) or equivalents thereof, that store data and programs that may be executed by the corresponding processor.");

and wherein the information bits include user data and control data (para [0017] "Generally, an embodiment of the present invention encompasses a method for transmitting uplink control signaling and uplink user data in an OFDM communication system comprising receiving user data non-associated/data associated control signaling, receiving user data, puncturing the user data non-associated/data associated control signaling into the user data stream to produce a data stream wherein the control and user data information are multiplexed, and conveying the punctured data stream to a radio access network via an air interface.").

It would have been obvious to one of ordinary skill in the art to modify the method, as disclosed by Franceschini, so as to include a computer-readable memory storing instruction involved in implementing the method and combining both user data and control data, as disclosed by Ghsoh, because being able to implement a method on a wireless communication device increases the number of situations where the method may be used, as well as, combining both user data and control data preserves the single carrier property of a single carrier OFDM system and avoids the high peak-to-average power ratio at the UE that results from conveying control signaling in a set of frequencies and time slots different from a set of frequencies and time slots used to convey user data (Ghsoh - para [0041]).

Claims 1-15 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.