

**UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD**

SAMSUNG ELECTRONICS CO., LTD.,
Petitioner

v.

ASUS TECHNOLOGY LICENSING INC.,
Patent Owner.

IPR2024-01217
Patent No. 10,104,658

DECLARATION OF MICHAEL ALLAN MARTIN DAVIES

I. Introduction	6
II. Qualifications.....	7
III.Scope of Opinion	12
IV. The '658 Patent	13
A. General Overview	13
B. Effective Filing Date	15
C. Prosecution History	15
D. The Challenged Claims	15
V. Person of Ordinary Skill in the Art (“POSITA”)	15
VI. Claim Construction	18
A. “signal”	18
B. “symbol”	19
C. “downlink control region of a subframe” and “data region of the subframe” 25	
D. “resources in different symbols of a data region of a subframe”	28
E. “a length of the downlink control region is two symbols”	30
VII. Prior Art Overview	30
A. Lindh (Ex-1004).....	30
B. Sesia (Ex-1005).....	31
C. Kim (Ex-1006)	32
D. Tooher (Ex-1007).....	32
E. 3GPP-36.300 (Ex-1009).....	33
F. R1-112517 (Ex-1010)	34
G. Applicant-Admitted Prior Art (“AAPA”)	35
VIII. Ground 1: Lindh in view of Tooher renders Obvious Claims 11-24.....	37
A. Scope and Content of Prior Art.....	37
B. Challenged Claims	41
1. [11.0] A method for a User Equipment (UE), comprising:	41
2. [11.1] communicating with a network node in a cell via downlink and uplink transmissions, wherein the downlink and uplink transmissions are	

- organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;..... 42
3. [11.2] monitoring, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe,..... 45
4. [11.3] and not monitoring a common signal in the at least one first symbol; and..... 48
- [11.4] monitoring, in the cell, the common signal in at least one second symbol of the downlink control region,..... 48
5. [11.5] wherein the common signal and the UE specific signal indicate resources in different symbols of the data region of the subframe. 52
6. [Claim 12] The method of claim 11, wherein the common signal and the UE specific signal indicate resources in completely different or partially different symbols of the data region of the subframe. 64
7. [Claim 13] The method of claim 11, wherein the UE monitors the UE specific signal in the second symbol..... 65
8. [Claim 14] The method of claim 11, wherein the UE does not monitor the UE specific signal in the at least one second symbol. 65
9. [Claim 15] The method of claim 11, wherein the UE specific signal is signaling indicating resource allocation, a signaling indicating HARQ (Hybrid Automatic Repeat request) feedback, and/or a reference signal for demodulation..... 67
- 10.[Claim 16] The method of claim 11, wherein the common signal is a signaling indicating a system frame number (SFN), a signaling indicating resource allocation for a broadcast message, a syndication signal, or a reference signal for DL radio condition measurement. 68
- 11.[Claim 17] The method of claim 11, wherein a length of the downlink control region is two symbols and the UE does not monitor the UE specific signal in the at least second symbol. 69
- 12.[18.0] A User Equipment (UE) for communication with a network node, comprising: 72
- 13.[18.0.1] a control circuit; [18.0.2] a processor installed in the control circuit; and [18.0.3] a memory installed in the control circuit and operatively coupled to the processor; [18.0.4] wherein the processor is configured to execute a program code stored in the memory to:..... 72

14.[18.1] communicate with the network node in a cell via downlink and uplink transmissions, wherein the downlink and the uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;.....	73
15.[18.2] monitor, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe,.....	73
16.[18.3] and not monitoring a common signal in the at least one first symbol; and.....	73
17.[18.4] monitor, in the cell, the common signal in at least one second symbol of the downlink control region,.....	73
18.[18.5] wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.	74
19.Claim 19-24	74
IX. GROUND 2: Kim in View of 3GPP-36.300 and R1-112517.....	74
A. Scope and Content of the Prior Art.....	74
B. Challenged Claims	83
1. [11.0] A method for a User Equipment (UE), comprising:	84
2. [11.1] communicating with a network node in a cell via downlink and uplink transmissions, wherein the downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;.....	84
3. [11.2] monitoring, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe, [11.3] and not monitoring a common signal in the at least one first symbol; and [11.4] monitoring, in the cell, the common signal in at least one second symbol of the downlink control region,.....	89
4. [11.5] wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.	95
5. [Claim 12] The method of claim 11, wherein the common signal and the UE specific signal indicate resources in completely different or partially different symbols of the data region of the subframe.	99
6. [Claim 13] The method of claim 11, wherein the UE monitors the UE specific signal in the second symbol.....	99
7. [Claim 14] The method of claim 11, wherein the UE does not monitor the UE specific signal in the at least one second symbol.	100

8. [Claim 15] The method of claim 11, wherein the UE specific signal is a signaling indicating resource allocation, a signaling indicating HARQ (Hybrid Automatic Repeat reQuest) feedback, and/or a reference signal for demodulation.....	100
9. [Claim 16] The method of claim 11, wherein the common signal is signaling indicating a system frame number (SFN), a signaling indicating resource allocation for a broadcast message, a synchronization signal, or a reference signal for DL radio condition measurement.....	101
10.[Claim 17] The method of claim 11, wherein a length of the downlink control region is two symbols and the UE does not monitor the UE specific signal in the at least one second symbol.....	102
11.[18.0] A User Equipment (UE) for communication with a network node, comprising:	104
12.[18.01] a control circuit:	105
[18.02] a processor installed in the control circuit; and.....	105
[18.03] a memory installed in the control circuit and operatively coupled to the processor;	105
13.[18.1] communicate with the network node in a cell via downlink and uplink transmissions, wherein the downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;.....	106
14.[18.2] monitor, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe,.....	106
15.[18.5] wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.	106
16.Claims 19-24.....	107
X. Conclusion.....	107

I. INTRODUCTION

1. My name is Michael Allan Martin Davies, and I have been retained by counsel (Greenberg Traurig, LLP) for Samsung Electronics Co., Ltd. (“Samsung”) as an expert witness in the *Inter Partes* Review of claims 11-24 (the “Challenged Claims”) of U.S. Patent No. 10,104,658 B2 (Ex-1001, the “’658 patent”).
2. I have also been retained to provide an analysis regarding the level of ordinary skill in the art at the time of the invention of the ’658 patent, and what a person of ordinary skill in the art would have understood at the time of the earliest application underlying the ’658 patent.
3. I have been informed that Asus Technology Licensing Inc. (hereinafter referred to as “Patent Owner” or “Patentee”) owns the ’658 patent. I have no financial interest in the Patent Owner of the ’658 patent, nor to my recollection have I had any contact with the Patent Owner for more than a decade, or the inventors of the ’658 patent. I also have no financial interest in Samsung.
4. All of the opinions stated in this declaration are based on my own expertise and professional judgement.
5. I am being compensated on an hourly basis for my work. My fee is not contingent on the outcome of any matter or on any of the technical positions explained or set forth in this declaration.
6. My opinions are based on my years of education, research and experience, as well as my investigation and study of relevant materials. The materials that I studied for this declaration include all the documents referenced in this declaration and the exhibits to Samsung’s

Petition for *Inter Partes* Review of U.S. Patent No. 10,104,658 B2 (Ex-1001, the “’658 patent”.)

7. I may rely upon these materials, my knowledge and experience, and/or additional materials to rebut arguments raised by the patent owner. Further, I may also consider additional documents and information in forming any necessary opinions, including documents that may not yet have been provided to me.
8. This declaration represents only those opinions I have formed to date. I reserve the right to revise, supplement, and/or amend my opinions stated herein based on new information and on my continuing analysis of the materials produced in this proceeding.

II. QUALIFICATIONS

9. I am Chairman and Senior Partner of Endeavour Partners, LLC, a Senior Lecturer and erstwhile Principal Investigator at the Massachusetts Institute of Technology, a Guest Lecturer at London Business School, and the Co-Founder and Chief Executive Officer of WKD.SMRT, Inc.
10. I have spent more than thirty years working in telecommunications, electronics, and related industries. I worked first as an engineer, then as a manager and executive, and now as an academic, consultant, expert, entrepreneur, and advisor. I have worked for a wide variety of technology and manufacturing companies on issues relating to manufacturing, logistics, supply chain, research and development, product development, platform development, systems engineering, technology, strategy, software development and innovation. My work

involves the connections amongst technology, innovation, new products and services, adoption and diffusion, consumer choice and behavior, and systems, architecture, platforms, and the emergence and evolution of business ecosystems.

11. I received a Bachelor of Arts and a Master of Arts in Engineering and in Electrical Sciences from St. Catharine's College at the University of Cambridge; a Master of Engineering in Cybernetics, Robotics and Microelectronics from the University of Durham; and a Master of Business Administration from London Business School (with Distinction). My educational work focused on engineering and electrical sciences, including mathematics, physics and computer science; cybernetics and robotics; microelectronics including the design of microchips; and management science, with a particular focus on technology and innovation, business strategy and systems thinking. I have appended my curriculum vitae to the end of this declaration.
12. I am currently Chairman and Senior Partner of Endeavour Partners, LLC, a strategy consulting firm with expertise in mobile, wireless and digital technologies, systems and businesses. I work with companies that create these products and services and those that are impacted by the business and technology forces at play in the mobile and digital sectors to help them anticipate technological innovations, consumer needs, and the emergence and evolution of business ecosystems so that they are capable of navigating opportunities for innovation and growth.
13. I have experience working throughout the mobile, wireless and digital sectors, including the convergence of mobile, broadband, Internet, and digital technologies. My work in this area includes the communications

sector, such as mobile devices including mobile phones (basic cellular phones, feature phones, smartphones), tablets, services and networks (broadband and Internet), computers (servers, PCs, components, hardware, and software), electronic hardware (semiconductors and ICs, PCB design, and manufacturing), consumer electronics, content (video, audio, and applications), and electronic commerce.

14. I have also worked on business and technology strategy with many leading mobile device manufacturers (“MDMs”) including HTC, Samsung, Nokia, Motorola, Sony Ericsson, and Mitsubishi Electric; supply chain companies such as Qualcomm and Analog Devices; and many leading network operators and service providers, including AT&T, Verizon, Vodafone, Sprint Nextel, British Telecom (BT), Deutsche Telekom, Virgin Mobile, Optus, and Telecom New Zealand.
15. I have significant experience serving as an expert consultant in this field. I served as an industry expert for the Department of Justice in 2011 in the anti-trust investigation (Civil Action No. 11-01560 (ESH)) of the proposed AT&T and T-Mobile merger. In this role, I analyzed the impact of the proposed merger, in particular as it related to consumer choice and to the technology and the economics of mobile networks and mobile services.
16. I also served as an industry expert for the Department of Justice in 2019 in the anti-trust investigation of the proposed T-Mobile and Sprint merger. In this role, I again analyzed the impact of the proposed merger, in particular as it related to consumer choice and to technology and the economics of mobile networks and mobile services. Additionally, I am serving as a technical and industry expert for the Department of Justice

in the anti-trust investigation of Google, LLC (District Court for the District of Columbia Case No. 1:20-cv-03010-APM).

17. I also served as an industry expert for the Department of Justice, Anti-Trust Division, Media, Entertainment, and Communications Section in 2022 during a recent major global anti-trust investigation in the communications services sector. Internationally, I served as an industry expert on the public interest in 2022 for the Competition Bureau Canada during its assessment of the proposed acquisition of Shaw Communications by Rogers Communications.
18. I am a Senior Lecturer at the Massachusetts Institute of Technology (MIT) where I have held posts in both the School of Engineering (in Aero/Astro) and in the Sloan School of Management, where I have created and taught courses in fundamental and advanced topics in technology strategy, in systems engineering, in the leadership of high-tech businesses, and in integrated design and management. I have been responsible for creating, managing, and teaching two capstone leadership courses for postgraduate students, the Systems Leadership & Management Lab and Praxis programs, and for teaching the capstone leadership courses for undergraduates in the Gordon Engineering Leadership program. I teach topics including creative innovation, value creation, emerging technologies, product management, product marketing, basic finance and business models, pricing and marketing, competitive analysis, market opportunity identification, funding entrepreneurship, data-driven decision making and decision-making under uncertainty.

19. I have also been a Principal Investigator at MIT and have typically supervised the master's thesis work of several students each year, much of which also focuses on issues related to mobile and digital ecosystems and innovation. I also have supervised theses that have been the basis for being spun off as companies, and received funding from the National Science Foundation. I am the creator and co-leader of the program on Breakthrough Innovation, and I also teach multiple modules of the Technology Leadership Program, including a significant portion of the core course.
20. I have been responsible for organizing and teaching the New Technology Ventures program at London Business School, which is designed to enable would-be entrepreneurs to evaluate novel technologies and ideas, many of them in the mobile and digital industries, and turn them into new entrepreneurial ventures. Additionally, I am the creator and course Academic Director for the path-breaking course on The Business of AI.
21. I have held significant leadership roles in the industry. I was the New Zealand representative to the International Telecommunication Union Radiocommunication Sector (ITU-R), the international standards making body, including the ITU-R, Task Group 8/1. I was elected as a Vice-Chairman of the Global System for Mobile Communication Memorandum of Understanding (the largest group of mobile network operators worldwide, which is now the GSMA with nearly 800 members) and was a founder and Chairman of its 3rd Generation Interest Group and have also chaired government working parties on PCS Spectrum.

22. I have been the Chairman of the Massachusetts Technology Leadership Council Mobile Cluster, and served on the Board of Advisors for the Department of Systems Engineering at the U.S. Military Academy at West Point, on the Board of Directors of the Kendall Square Association. I am an advisor to WGBH, a public television station, public radio station and public media production house located in Boston, Massachusetts, and to PRX, the leading public audio podcasting business.

III. SCOPE OF OPINION

23. I have been asked to provide my opinions regarding whether claims 11-24 (the “Challenged Claims”) of the ’658 patent are unpatentable pursuant to the following grounds:
- Whether claims 11-24 are rendered obvious under AIA 35 U.S.C. §103 by U.S. Patent No. 2012/0207099 A1 to Lindh et al. (“Lindh”, Ex-1004) in view of U.S. Patent No. 2017/0290008 A1 to Tooher et al. (“Tooher”, Ex-1007).
 - Whether claims 11-24 are rendered obvious under AIA 35 U.S.C. §103 by U.S. Patent No. 9,408,096 B2 to Kim (“Kim”, Ex-1006) in view of 3GPP TS36.300 LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description (“TS36.300”, Ex-1009), and R1-112517, TSG-RAN Working Group 1 Meeting #66 “Discussion on ePDCCH Design issues”, Samsung (“R1-112517”, Ex-1010).

24. This Declaration, including the exhibits hereto, sets forth my opinion on these topics.

IV. THE '658 PATENT

A. General Overview

25. The '658 patent is directed to common control signaling and UE-specific control signaling in wireless communication systems. (Ex-1001 at 1:14-19, 2:38-67.) One of ordinary skill in the art would understand a “UE” is a wireless communication device or access terminal that communicates with a network node (commonly called a base station, eNB, and the like). (*Id.* at 3:35-42.)
26. The '658 patent includes Applicant Admitted Prior Art (“AAPA”) figures 5-14 and 11 columns of corresponding text. (Ex-1001 at FIGs. 5-14, 5:18-16:8.) The alleged invention is described in the context of known wireless networks, including 3GPP LTE and LTE-Advanced, as described in the AAPA. (*Id.* at 2:38-67 (describing conventional networks, modulation techniques, and standards, and incorporating various standards and publications by reference); 5:18-16:8 (describing LTE standards and the related AAPA figures, as noted above).)
27. The '658 patent focuses on downlink subframes:

“SUMMARY

A method and apparatus for delivery of control signaling in a wireless communication system are disclosed...The method also includes transmitting, in the cell, a UE specific signal in a first symbol of a downlink control region of a subframe of the multiple subframes, wherein the network node is not allowed to transmit a common signal in the first symbol.” (*Id.* at 1:41-55.)

“FIG. 15 is a diagram of a subframe 1500 in according with one exemplary embodiment. In general, the concept of the invention is that in downlink control region 1505 of a subframe, there is at least a first part of the downlink control region (e.g., consisting of at least one symbol) used to transmit UE specific downlink control signaling (e.g., type 2) 1510, and not used to transmit common downlink control signaling (e.g., type 1). Then, the network could flexibly use the first part of downlink control region to transmit signaling on beam(s) of certain UE(s), and is not limited by the beams for type 1 signaling.” (*Id.* at 16:9-19.)

28. FIG. 15 illustrates a subframe 1500:

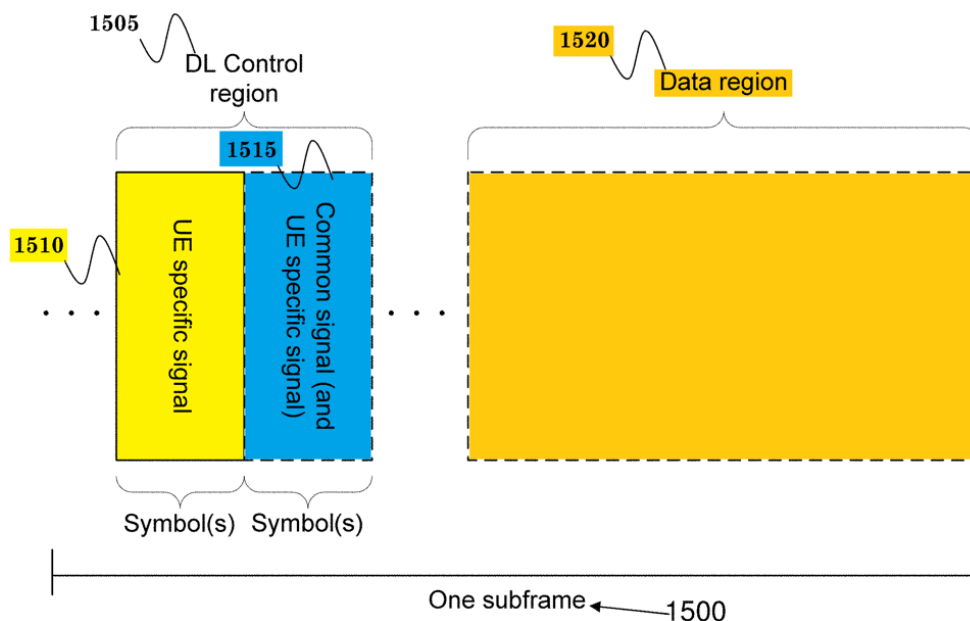


FIG. 15

Figure 1 *The Subframe of the '658 patent with UE specific and common signals in the downlink control region and a data region (Ex-1001 at FIG. 15.)*¹

¹ I adopt and refer to Petitioner’s highlighting, emphasis, and annotations throughout this Declaration and note that highlighting, emphasis, and annotations were added by Petitioner unless otherwise noted.

29. The subframe has distinct regions for control (1505) and data (1520, highlighted by the Petitioner in orange), with the control region having UE specific control signal portions (1510, highlighted by the Petitioner in yellow) and common (1515, highlighted by the Petitioner in blue) control signal portions.

B. Effective Filing Date

30. The '658 patent was filed June 7, 2016 and claims priority to two provisional applications filed June 12, 2015 and June 23, 2015. (Ex-1001, (60).) The prior art relied on herein is prior art with respect to all three dates. My opinion regarding the level of ordinary skill in the art would be the same regardless of which date applies.

C. Prosecution History

31. I adopt counsel's exposition of the prosecution history where the patent examiner issued a single non-final rejection on November 6, 2017, rejecting claims over Takano (U.S. Patent App. Pub. 2014/0119349) alone and in view of Guey (US2016/0087707). (Ex-1002 at 373-78.)

D. The Challenged Claims

32. Petitioner challenges claims 11-24; claims 11 and 18 are independent.

V. PERSON OF ORDINARY SKILL IN THE ART ("POSITA")

33. I understand that my assessment of the claims of the '658 patent must be undertaken from the perspective of what would have been known or understood by a person having ordinary skill in the art, reading the '658 patent on its priority date and in light of the specification and file history of the '658 patent. I may refer to such a person as a "POSITA."

34. I understand that my analysis and opinions expressed in this declaration must be rendered based on the perspective of a POSITA as of the priority date of the '658 patent. I also understand that a POSITA is a hypothetical person who is presumed to know the relevant art at the time of the alleged invention claimed in the '658 patent.
35. I further understand that in determining the level of ordinary skill in the art, I am to consider factors including:
- the type of problems encountered in the art or field of invention,
 - prior art solutions to those problems,
 - the rapidity with which innovations are made,
 - sophistication of the technology, and
 - the educational level of active workers in the field.
36. I have been instructed to assume a person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the qualities reflected by the factors discussed above.
37. I understand that a POSITA is a person of ordinary creativity, but not an automaton, and that a POSITA can often fit multiple patents or prior art references together like pieces of a puzzle as a result of this ordinary creativity. I also understand that I may consider the inferences and creative steps that a POSITA would employ. In addition, I understand that a POSITA would necessarily have been capable of understanding the scientific and engineering principles applicable to the pertinent art.
38. I also understand that when I consider what would have been obvious to a POSITA, I am not considering what would have been obvious to

me at the time, nor to the inventors, judges, laymen, those skilled in other arts, or to geniuses in the art.

39. A POSITA in the field of the '658 patent, as of its first provisional filing date of June 12, 2015, would have had at least a bachelor's degree in electrical engineering, computer science, computer networking, or network engineering and familiarity with telecommunications. The POSITA would have also had some familiarity with the relevant 3GPP standards as of this time, and two years of experience working in a field involving wireless communications. Additional education may serve as a substitute for a lack of experience and vice versa.
40. In my own experience working in this field, experience with reviewing 3GPP standards including technical specifications and proposals was important for individuals working in the field. Such materials informed those working in the field how 3GPP standard networks functioned, including for well-known networks like LTE.
41. The educational level of active workers in the field of the invention also informs my opinion. Such individuals usually had at least a bachelor's degree in electrical engineering, computer science, computer networking or networking engineering or a related discipline and at least two years of experience working in the field of wireless communications networks or in academic research related thereto.
42. As of June 12, 2015, I had more than ordinary skill in the art. I am, however, familiar with the skills and knowledge possessed by those I would have considered to be of ordinary skill in the art as of that date. The same is true as of the June 7, 2016 filing date of the '658 patent

and the time period between the two dates. When I refer to the understanding of a POSITA, I am referring to the understanding of such a person as of June 12, 2015.

VI. CLAIM CONSTRUCTION

43. I do not believe any claim constructions are required given the arguments raised in the Petition and this declaration, and I interpret the claims at issue in accordance with their ordinary and customary meanings to the extent possible. 37 C.F.R. §41.100(b). Below, I have addressed several potentially-ambiguous aspects of the Challenged Claims.

A. “signal”

44. The term “signal” is used in the Challenged Claims, as well as several hundred times in the specification. The “common signal” and the “UE specific signal” of claims 11 and 18 cover control signals (e.g., “control signaling” or “signalings” such as a signal on PDCCH for allocating resources, Ex-1001 at 16:30-52) and reference signals (see, e.g., claims 15-16, 21-22).

45. In the ’658 patent two types of downlink signaling are introduced: Common signaling (type 1) and UE specific signaling (type 2). Common signaling is intended for all or a plurality of UEs in the cell or UEs connecting to the TP or TRP and is transmitted periodically. (Ex-1001 at 15:54-58.) Examples include:

“A signaling indicating system frame number of the cell, TP, or TRP;

A signaling (e.g. on PDCCH) allocate resource for a broadcast message (e.g., system information, paging, random access response) for UE(s) in the cell or for UE(s) connecting to the TP or TRP;

A synchronization signal for UE(s) in the cell or for UE(s) connecting to the TP or TRP to obtain downlink timing; and/or

A reference signal for UE(s) to measure downlink condition (e.g. CRS).” (Ex-1001 at 16:42-52.)

46. Examples of UE specific signaling include:

“A signaling (e.g. on PDCCH) to allocate resource for a DL or UL transmission;

A signaling (e.g., on PHICH) to carry HARQ feedback in response to at least one UL transmission; and or

A reference signal used to help an UE demodulate a DL transmission (e.g., DMRS).” (Ex-1001 at 16:33-38.)

B. “symbol”

47. The word “symbol” appears in challenged claims 11-14, 17-20, and 23-24. It appears to refer to the shortest duration subclass within the time domain of a radio frame that is used to transmit data.

48. In full duplex FDD LTE, the uplink and downlink are separated in frequency and are transmitted continuously and synchronously.² Radio transmissions are organized into 10 ms radio frames in the time domain

²

See
https://helpfiles.keysight.com/csg/89600B/Webhelp/Subsystems/lte/content/lte_overview.htm

each of which are subdivided into ten 1ms subframes.³ Each subframe is further subdivided into two 0.5 ms slots, and each slot consists of seven 66.7 μ s symbols.⁴ Within a symbol there is a ‘cyclic prefix’ and real symbol data. The cyclic prefix aids in combating intersymbol interference by inserting a guard period (where the end of the previous symbol is copied to the beginning of the next symbol) before each symbol.⁵ A normal cyclic prefix is 4.69 μ s long, thus a 0.5 ms slot can accommodate seven symbols with normal cyclic prefix each of which occupy $(66.7 \mu\text{s} + 4.69 \mu\text{s})$ 71.39 μ s.⁶ An extended cyclic prefix is 16.67 μ s long, thus a 0.5 ms slot can only accommodate 6 symbols with

3

See

https://www.sharetechnote.com/html/FrameStructure_DL.html#:~:text=Each%20of%20the%20frame%20consists,of%20which%20is%2066.7%20us.

4

See

https://www.sharetechnote.com/html/FrameStructure_DL.html#:~:text=Each%20of%20the%20frame%20consists,of%20which%20is%2066.7%20us.

⁵ *See* <https://www.electronics-notes.com/articles/connectivity/4g-lte-long-term-evolution/ofdm-ofdma-scdma-modulation.php>

⁶ *See* <https://www.linkedin.com/pulse/lte-frame-structure-bikas-singh>

extended cyclic prefix each of which occupy $(66.7 \mu\text{s} + 16.67 \mu\text{s}) 83.37 \mu\text{s}$.⁷

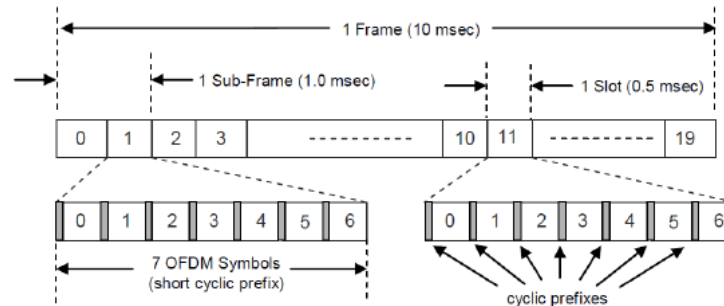


Figure 2 *One frame of FDD LTE in the time domain, illustrating how a frame is broken down into sub-frames, slots, and symbols.*⁸

49. The smallest time-frequency division in LTE is a resource element (RE) which is comprised of one OFDM symbol ($66.7 \mu\text{s}$) in the time domain and one OFDM sub-carrier (15 kHz sub-carrier spacing) in the frequency domain.^{9,10} The smallest unit that can be scheduled for transmission to a UE is a physical resource block (PRB), which is comprised of twelve OFDM sub-carriers and one OFDM slot (seven OFDM symbols).¹¹ Note that AAPA FIG. 7 suggests this interpretation,

⁷ See <https://www.linkedin.com/pulse/lte-frame-structure-bikas-singh>

⁸

See

https://www.sharetechnote.com/html/FrameStructure_DL.html#:~:text=Each%20of%20the%20frame%20consists,of%20which%20is%2066.7%20us.

⁹ See <https://www.sciencedirect.com/topics/computer-science/resource-element>

¹⁰ Note: in order to maintain orthogonality in LTE OFDM systems, the symbol rate is the inverse of the fixed sub-carrier spacing ($1/15 \text{ kHz} = 66.7 \mu\text{s}$)

¹¹ See <https://www.sciencedirect.com/topics/computer-science/resource-element>

as a standard 0.5 ms subframe slot¹² has a time duration or length of 7 OFDM symbols; a full 1 ms subframe would have 14 OFDM symbols. FIG. 7 it is a reproduction of the figure below.

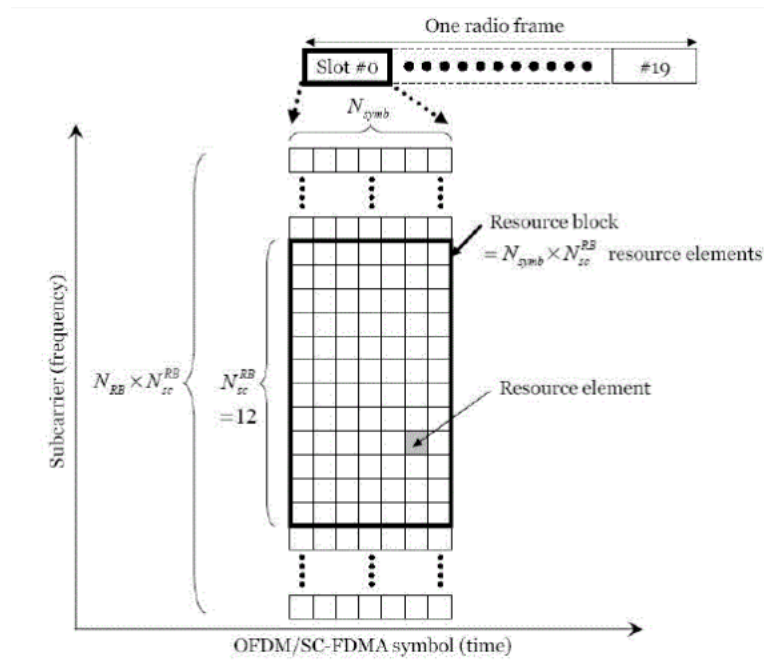


Figure 3 *LTE resource grid where the smallest unit is a resource element comprised of one symbol (in the time domain) and one sub-carrier (in the frequency domain).¹³ (Ex-1001 at AAPA FIG. 7.)*

50. The '658 patent specification indicates an identical interpretation of symbol:

“...the downlink and uplink transmissions are organized into radio frames and each radio frame contains multiple subframes and each subframe contains multiple symbols.” (Ex-1001 at 1:47:50.)

¹² See Ex-1001 [AAPA] at 5:36-40 “Each 10 ms radio frame consists of two half-frames of 5 ms each. Each half-frame consists of eight slots of length 0.5 ms and three special fields: DwPTS, GP, and UpPTS.”

¹³ See <https://www.ni.com/docs/en-US/bundle/rfmw-waveform-creator/page/lte-slot-structure.html>

51. The '658 patent also discusses how a data stream can be transmitted over a physical downlink channel by mapping them to symbols in a physical resource element:

“In one embodiment, each data stream is transmitted over a respective transmit antenna. TX data processor 214 formats, codes, and interleaves the traffic data for each data stream based on a particular coding scheme selected for that data stream to provide coded data.

The coded data for each data stream may be multiplexed with pilot data using OFDM techniques. The pilot data is typically a known data pattern that is processed in a known manner and may be used at the receiver system to estimate the channel response. The multiplexed pilot and coded data for each data stream is then modulated (i.e. symbol mapped) based on a particular modulation scheme (e.g., BPSK, QPSK, M-PSK, or M-QAM) selected for that data stream to provide modulation for each data stream may be determined by instructions performed by the processor 230.

The modulation symbols for all data streams are then provided to a TX MIMO processor 220, which may further process the modulation symbols (e.g., for OFDM). TX MIMO processor 220 then provides N_T to N_T transmitters (TMTR) 222a through 222t. In certain embodiments, TX MIMO processor applies beamforming weights to the symbols of the data streams and to the antenna from which the symbol is being transmitted.” (Ex-1001 at 3:50-4:6.)

52. The dependent claims of the '658 patent also indicate that the above interpretation of “symbol” is appropriate by requiring “a downlink control region is two symbols.” (Ex-1001 at claims 17, 23.)

53. Moreover, FIG. 15, which illustrates “the concept of the [alleged] invention”, shows a subframe structure (1500) having a known duration (e.g., 1 ms). (Ex-1001 at 16:10-16.)

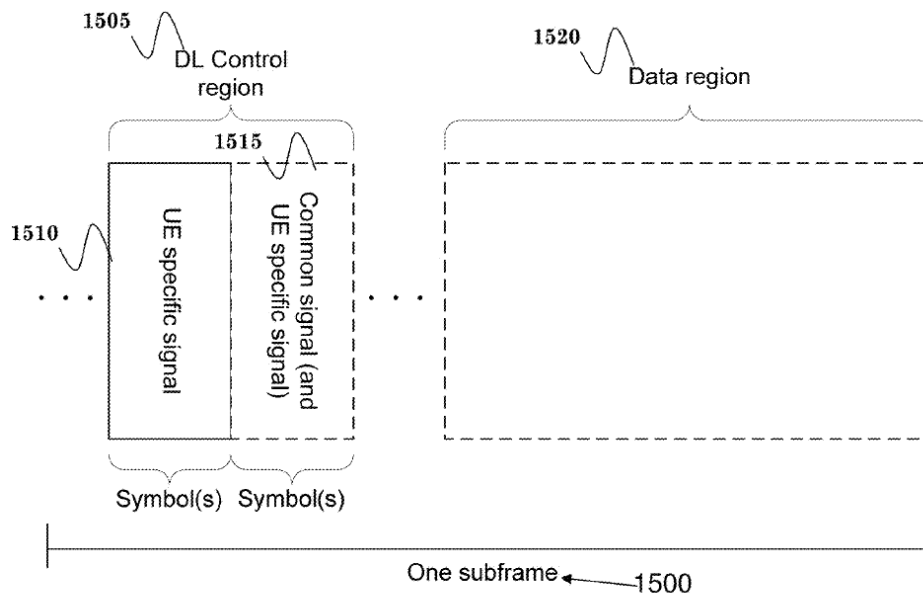


FIG. 15

Figure 4 *Subframe structure (1500) associated with the Patentee’s alleged invention (Ex-1001 at FIG. 15.)*

54. The horizontal axis of Patentee’s FIG. 15 indicates time and one in ordinary skill in the art would understand that the vertical axis indicates frequency, given the time-frequency aspect of LTE. As shown in FIG. 15, the subframe is further subdivided into symbols in the time domain, indicating “symbols” reflect a time length or duration. (Ex-1001 at FIG. 15.)
55. The prior art uses the term “symbol” in the same manner as the ’658 patent. Indeed, as discussed below in the prior art overview section as well as Grounds 1-2, a typical example of an LTE subframe structure

had a control region length of 3 OFDM symbols and a data region length of 11 OFDM symbols. This typical structure and variations of it are discussed below.

C. “downlink control region of a subframe” and “data region of the subframe”

56. The Challenged Claims require a subframe having a “control region” and a “data region”. FIG. 15 provides an example:

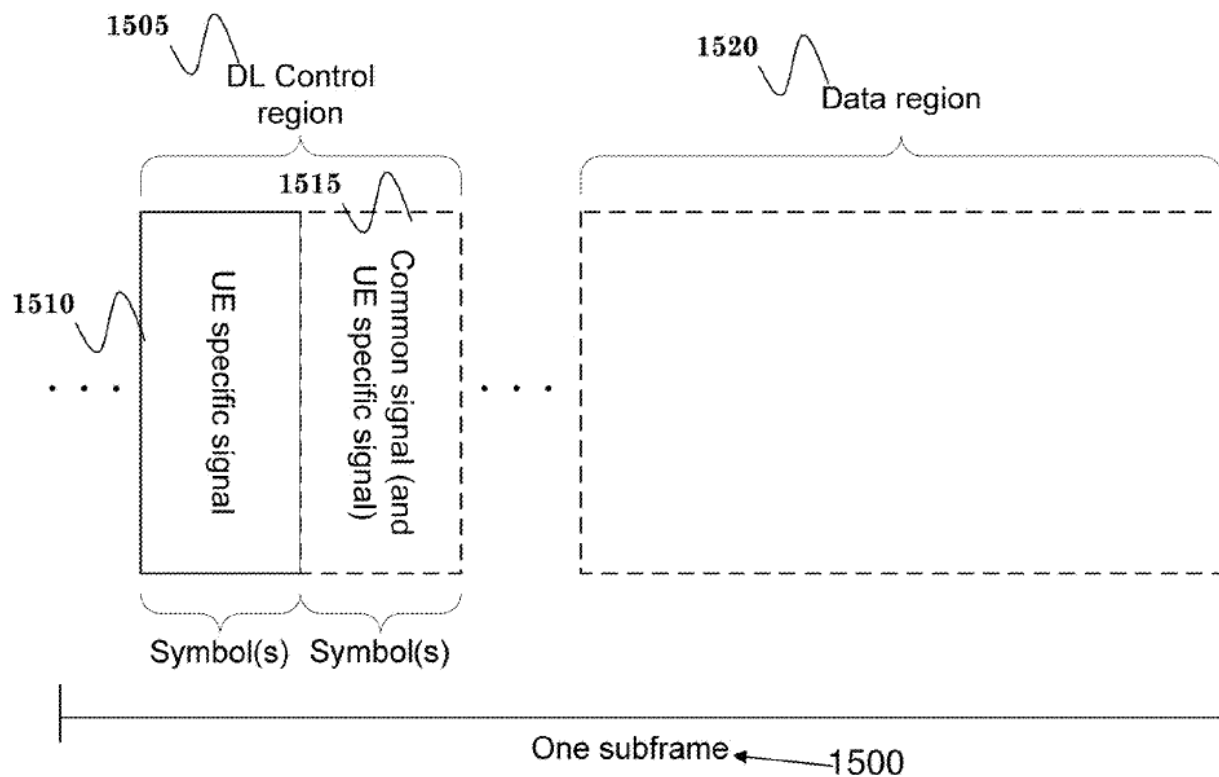


FIG. 15

Figure 5 *Subframe structure (1500) associated with the alleged invention (Ex-1001 at FIG. 15.)*

57. As shown in FIG. 15, two regions 1505 (the DL control region) and 1520 (the data region) are distinctly defined. Representations of typical

LTE subframe structures in the prior art also reflect a similar separation between the two regions:

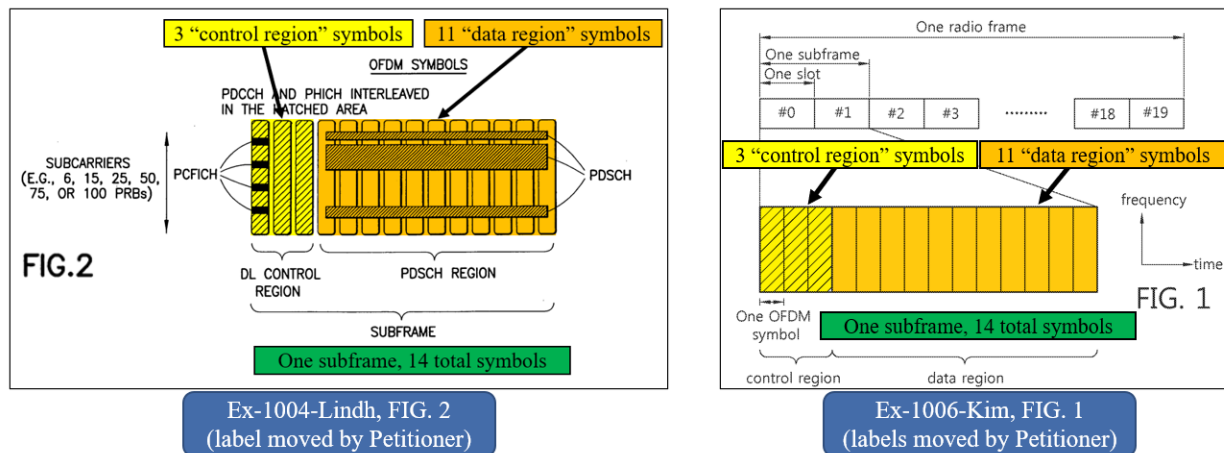


Figure 6 *Subframe structures illustrated in Lindh and Kim both demonstrate two distinct regions for control and data (Ex-1004-Lindh at FIG. 2 and Ex-1006-Kim at FIG. 1.)*

58. As the complexity of LTE increased (e.g., with the introduction of beamforming and Carrier Aggregation (CA)) the spectral efficiency of resources for data transmission increased (i.e., the same resources could be used to transmit more data), it became necessary to increase the capacity of the control region (which is responsible for allocating resources in the data region). As a result, control signals migrated into the erstwhile data region:

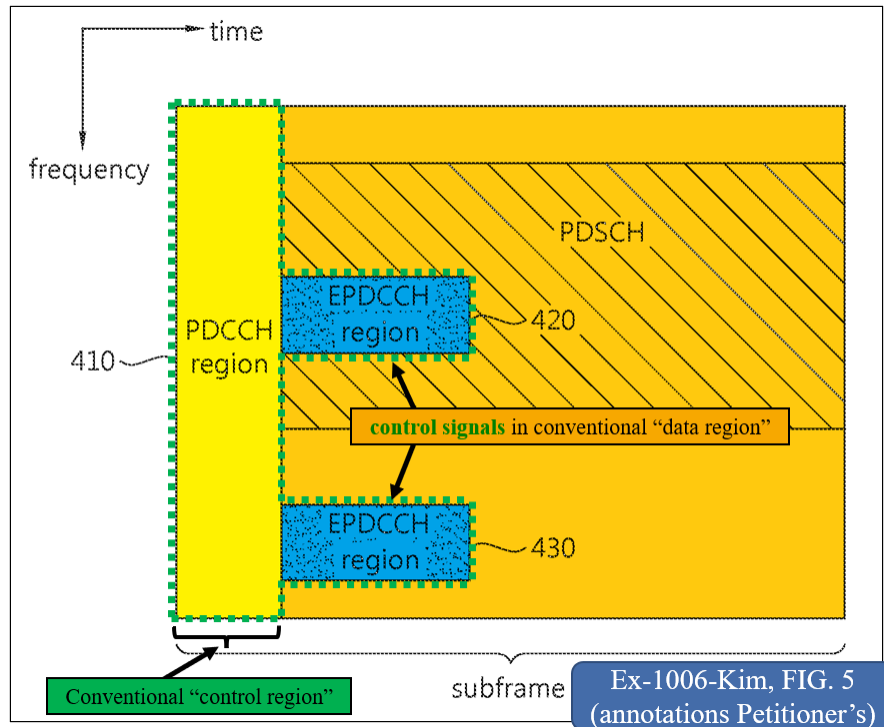


Figure 7 *Kim FIG. 5 illustrates how the control capacity has increased from the PDCCH region located in the conventional “control region” to the PDCCH region plus the EPDCCH region (which are control signals located in the conventional “data region”) (Ex-1006-Kim FIG. 5.)*

59. Kim explains that control information in the figure above is monitored in both the PDCCH region (highlighted yellow by the Petitioner) and the EPDCCH regions (highlighted blue by the Petitioner). (Ex-1006-Kim at [0087]-[0098].) One of ordinary skill in the art would understand that the EPDCCH region provides control information within the conventional data region. Thus, if the claims allow portions of the control region and data region to occupy the same symbol(s), as I understand Patentee interprets the claims, then Kim discloses such an arrangement as shown herein.

D. “resources in different symbols of a data region of a subframe”

60. Limitations 11.5 and 18.5 require “wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.” The word “different” in this context could carry a variety of meanings, but appears to mean here that the symbols occupied by a UE-specific signal cannot be coextensive with the symbols for a common signal.
61. First, “different” cannot be limited to “completely different” because dependent claims (12, 19) cover symbols that are “completely different or partially different,” and I understand dependent claims cannot be broader than their corresponding independent claims.
62. Second, the specification suggests that the claimed difference means that the “indicate[d] resources” cannot be coextensive in terms of symbols:
- “[A] signaling transmitted in the first part of the downlink control region of the subframe could be associated with resources in first symbol(s) of the data region in the subframe; and a signaling transmitted in the second part of the downlink control region of the subframe could be associated with resources in second symbol(s) of the data region in the subframe. The first symbol(s) and the second symbol(s) are completely or partially different.”
(Ex-1001 at 17:15-22.)
63. The language of the specification is slightly different than in the claims (e.g., a signal is “associated with resources” rather than “indicate[s] resources”), although it appears to convey the same concept: a difference exists unless two indicated resources are coextensive (occupying exactly the same symbols). One of ordinary skill in the art

would understand that two indicated resources are different unless they occupy the same symbol(s).

64. If a UE specific signal is transmitted in the downlink control region it could be associated with a resource in the data region of the subframe. That resource may span some or all of the symbols of the data region. For instance, a UE specific signal could be a reference signal used to help a UE demodulate a DL transmission (e.g., DMRS) wherein these demodulation instructions could be applied to symbol(s) in the data region. (Ex-1001 at 16:37-38.)
65. Additionally, if a common signal is transmitted in downlink control region it could also be associated with a resource in the data region of the subframe, and, as above, the resource may span some or all of the symbols of the data region. For instance, a common signal could be a reference signal for the UE(s) to measure downlink radio condition (e.g., CRS) wherein the downlink radio condition measurement would be conducted in symbol(s) of the data region. (Ex-1001 at 16:51-52.)
66. When two different resources of the data region are not located in exactly the same symbols (e.g., if one resource is in symbols 4-14 and the other is in symbols 4-13), they are located in “different” symbols. (Ex-1001 at 17:15-22.)
67. The prior art relied on herein discloses indicated resources in different symbols of a data region under any reasonable construction.

E. “a length of the downlink control region is two symbols”

68. Dependent claims 17 and 23 require that the “length of the downlink control region is two symbols.” By changing from “at least one” in the independent claims to the word “is” in the dependent claims 17 and 23, Patentee appears to limit the control region to exactly two symbols.

VII. PRIOR ART OVERVIEW

A. Lindh (Ex-1004)

69. Lindh is U.S. Patent App. Pub. 2012/0207099, filed February 11, 2011 and published August 16, 2012. I understand Lindh is prior art.
70. Lindh discloses UEs that communicate with a network node (eNB)—communications from the UE to the eNB are uplink communications, and communications from eNB to UE are downlink communications. (Ex-1004-Lindh at FIGs. 1-2, [0050]-[0062], [0080]-[0082].) For example, Lindh’s FIG. 4 discloses a downlink subframe structure (470) having two portions of a control region (410, 420), one for legacy control signals (420, highlighted by the Petitioner in yellow) and the other for enhanced control signals (410, highlighted by the Petitioner in

blue), a data region (orange), and resources (green and purple) located in the data region:

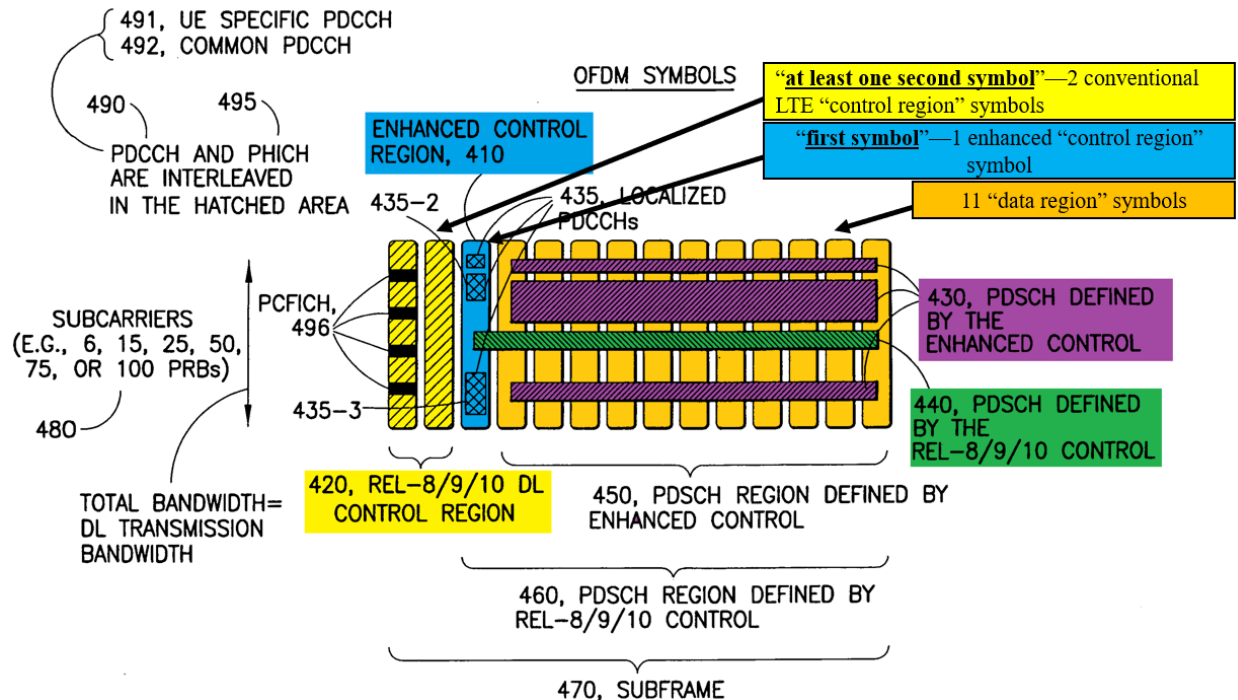


FIG. 4

Figure 8 FIG. 4 of Lindh demonstrating a subframe with a control region and a data region, with resources indicated by the control region located in the data region (Ex-1004-Lindh at FIG. 4; [0067], [0095]-[0112] (describing FIG. 4 and related FIG. 5).)

B. Sesia (Ex-1005)

71. Sesia is a 2011 book entitled "LTE: The UMTS Long Term Evolution—From Theory to Practice. I understand Sesia is prior art.
72. As the Foreword states, Sesia "provides a thorough, authoritative and complete tutorial of the LTE system" inclusive of LTE-Advanced. (Ex-1005-Sesia at 29.) In relevant part, Sesia provides express details regarding how "special purpose" information was conventionally transmitted in LTE.

C. Kim (Ex-1006)

73. Kim is U.S. Patent Application Publication No. 2014/0307560, which published on October 16, 2014. I understand Kim is prior art.
74. Kim discloses UEs communicating with a network node (eNB) over a network using downlinks and uplinks. (Ex-1006-Kim at [0024]-[0027].) Kim further discloses downlink control channel structures corresponding to those of the Challenged Claims under at least Patentee’s apparent interpretation of the claim language. (*See* §VIII.)
75. FIG. 1 illustrates a conventional radio frame having 10 subframes, with 2 slots and 14 OFDM symbols per subframe (separated into 3 control region symbols and 11 data region symbols). (Ex-1006-Kim at FIG. 1.) Kim further discloses an enhancement to the conventional subframe structure that comprises “enhanced” control regions called “EPDCCH” regions. (Ex-1006-Kim at FIG. 5, [0020]; *see also id.* at [0087]-[0101].)

D. Tooher (Ex-1007)

76. Tooher is U.S. Patent App. Pub. 2017/0290008, filed September 8, 2015 and claiming priority to two provisionals, including U.S. Provisional App. No. 62/047,610, filed September 8, 2014 (Ex-1008-Tooher-Prov, “Tooher-Prov”). I understand Tooher is prior art. The subject matter in Tooher that I discuss herein is disclosed in Tooher-Prov. To show this, I cite to both references in my analysis below.
77. Tooher discloses variable durations/locations for control signals and resources, including signals and resources found in a Physical Downlink Control Channel (“PDCCH”), Enhanced PDDCH (“EPDCCH”), and Physical Downlink Shared Channel (“PDSCH”).

78. For instance, Tooher's FIG. 5 discloses signals in a subframe's EPDCCH regions, and those signals may indicate corresponding data resources in PDSCH channels that are in different symbols. The example depicted in FIG. 5 shows one EPDCCH indicating a PDSCH resource allocation in symbols of time slot 1, while another EPDCCH indicates resource allocation in symbols of time slot 2. (E.g., Ex-1007-Tooher at FIG. 5, 0143; Ex-1008-Tooher-Prov at FIG. 4, 0093.)

E. 3GPP-36.300 (Ex-1009)

79. 3GPP-36.300 is a technical specification from 3GPP LTE Release 12, titled 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (Release 12). I understand that 3GPP-36.300 is prior art. (Ex-1012-Bishop at ¶¶47-52, 58-59.)

80. 3GPP-36.300 is referenced in the '658 patent, and I understand that Release 8 (v8.11.0) and Release 10 (v10.2.0) versions of the same specification are filed herewith. (Ex-1011-36.300-8.11.0; Ex-1015-36.300-v10.2.0). All three versions disclose LTE frame structures:

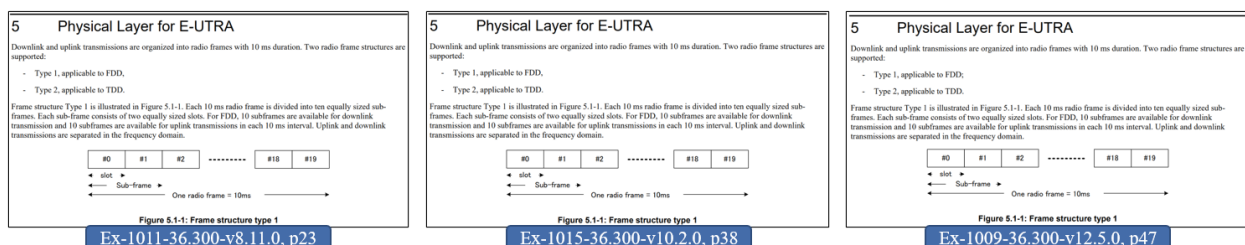


Figure 9 *Radio frame structures as laid out in LTE Release 12 (v. 12.5.0), Release 10 (v.10.2.0), and Release 8 (v.8.11.0) (Ex-1011-36-300-8.11.0 at pg. 23; Ex-1015-36.300-v10.2.0 at pg. 38, Ex-1009-36-300-12.5.0 at pg. 47.)*

81. Each .5ms slot is normally 7 symbols in duration. LTE uses two different types of symbols: OFDM symbols in the downlink direction,¹⁴ and SC-FDMA symbols in the uplink direction.¹⁵
82. I cite to Release 12 (Ex-1009) in this declaration in the Grounds below to simplify review (unless otherwise noted).

F. R1-112517 (Ex-1010)

83. R1-112517 is a 3GPP discussion document titled “Discussion on ePDCCH Design Issues.” It was submitted by Samsung for discussion at the 3GPP TSG-Ran #66 meeting held in Athens, Greece, in August 2011. I understand R1-112517 is prior art. (Ex-1012-Bishop at ¶¶53-59.)
84. R1-112517 discusses possible improvements for downlink control channel capacity, and accounts for related design concerns including resource allocation. R1-112517 teaches transmitting a PDCCH in a conventional control region and a corresponding PDSCH that occupies all data region symbols, while also teaching transmitting eCCEs in the

¹⁴ Ex-1009-36.300-12.5.0 at §5.1.1, p49; Ex-1011-36.300-8.11.0 at §5.1.1, p25; Ex-1015-36.300-10.2.0 at §5.1.1, p40.

¹⁵ Ex-1009-36.300-12.5.0 at §5.2.1, p52; Ex-1011-36.300-8.11.0 at §5.2.1, p28; Ex-1015-36.300-10.2.0 at §5.2.1, p43.

first slot of a subframe and corresponding PDSCHs in the second slot.
Fig.1(b) provides an example:

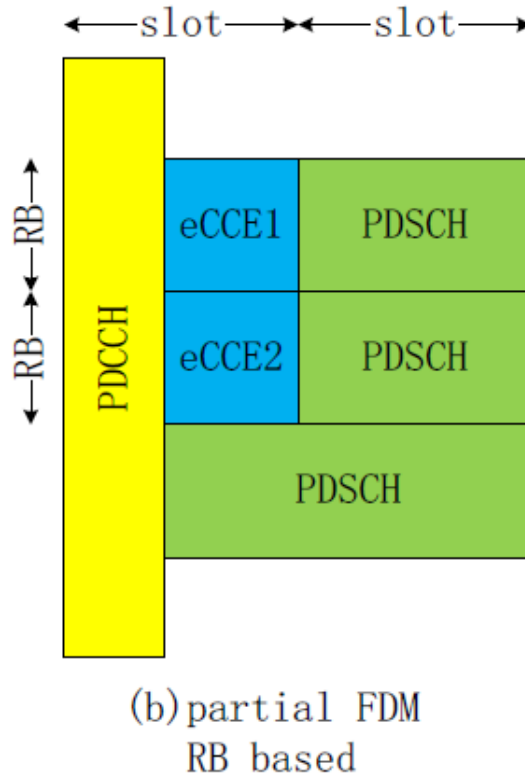


Figure 10 *The eCCEs allocate resources in the PDSCH region in the second slot of the subframe. (Ex-1010-R1-112517 at 2.)*

G. Applicant-Admitted Prior Art (“AAPA”)

85. Patentee labeled FIGS. 5-14 “PRIOR ART.” These figures and their corresponding descriptions show that many aspects of the Challenged Claims are AAPA, including the conventional LTE frame structure. For example, FIG. 5 shows a 10ms radio frame organized into 10 subframes, each subframe having 2 slots. FIGS. 7-8 show a slot having a 7-symbol duration.

86. Likewise, FIGS. 12-13 disclose a UE and base station communicating via UL and DL transmissions, and FIG. 14 discloses a subframe structure having the conventional separation between data and control regions.
87. The '658 patent also identifies conventional communications systems, including 3GPP LTE and LTE-A (Ex-1001 at 2:40-49) and incorporates-by-reference 3GPP technical specifications, including 3GPP-36.300 (Ex-1009). (Ex-1001 at 2:50-67.)

VIII. GROUND 1: LINDH IN VIEW OF TOOHER RENDERS OBVIOUS CLAIMS 11-24

A. Scope and Content of Prior Art

88. Ground 1 relies on Lindh and Tooher. Lindh discloses most elements of the Challenged Claims, including the downlink, uplink, radio frame, subframe, and symbol requirements of the claims. Lindh discloses a downlink subframe structure in which multiple data resources (located within purple- and green-highlighted regions of the orange-highlighted data region symbols) allocated by conventional (yellow region) and enhanced (blue region) control signals, as shown in FIG. 4:

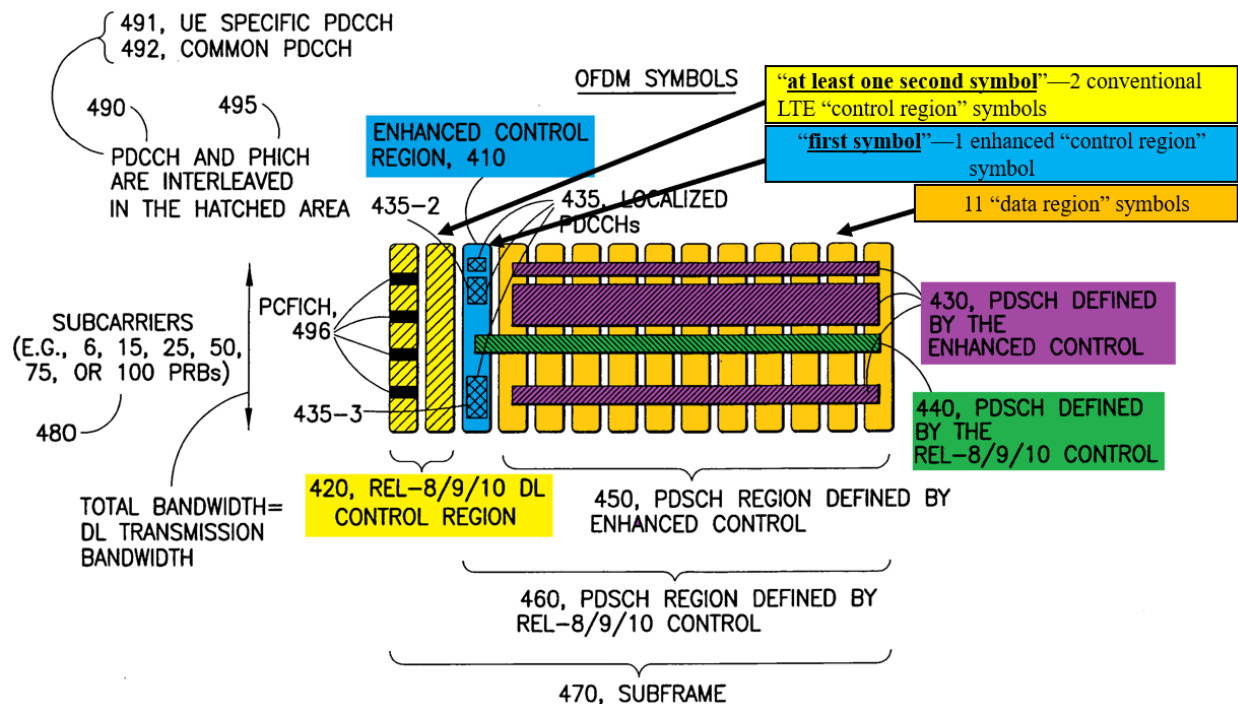


FIG. 4

Figure 11 FIG. 4 of Lindh demonstrates a subframe structure where common and enhanced control signals are used to allocate resources in the data region (Ex-1004-Lindh.)

89. Limitations 11.5 and 18.5 require “wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.” As detailed relative to Grounds 1 and 2 below, a UE looks for “common” signals in Lindh’s conventional control region (highlighted by the Petitioner in yellow) of Lindh, and looks for “UE specific” signals in Lindh’s enhanced control region (highlighted by the Petitioner in blue).
90. FIG. 4 does not expressly show a common signal and UE specific signal indicating resources in different symbols in Lindh’s data region. However, one of ordinary skill in the art would understand that a common signal and a UE specific signal would each indicate distinct resources in Lindh’s data region. One of ordinary skill in the art would understand that one or more common signal-indicated data resource(s) may be found in PDSCH symbols that do not span all 11 data region symbols. Likewise, one of ordinary skill in the art would understand that one or more UE specific-indicated data resource(s) may be found in PDSCH symbols that do not span all 11 data region symbols.
91. A POSITA would have had this understanding because there were typically at least 11 data region symbols, and it would be inefficient to reserve all 11 for a given data resource if fewer symbols were sufficient. Lindh teaches and suggests this by explaining that the positioning of the allocated data resources is not limiting: “the locations of the exemplary PDSCH 430 and 440 positions are merely illustrative and are not limiting.” (Ex-1004-Lindh at [0100].)
92. One of ordinary skill in the art would have reasonably understood paragraph [0100] to mean that the PDSCHs in Lindh may vary with

respect to position in both axes—both in terms of frequency bandwidth (vertical) and symbol duration (horizontal). Petitioner has illustrated how one of ordinary skill in the art would have understood this disclosure of Lindh using Lindh’s FIG. 4 and two modifications thereof below:

“It is noted that the locations of the exemplary PDSCH 430 and 440 positions are merely illustrative and are not limiting.” (Ex-1004-Lindh at 0100)

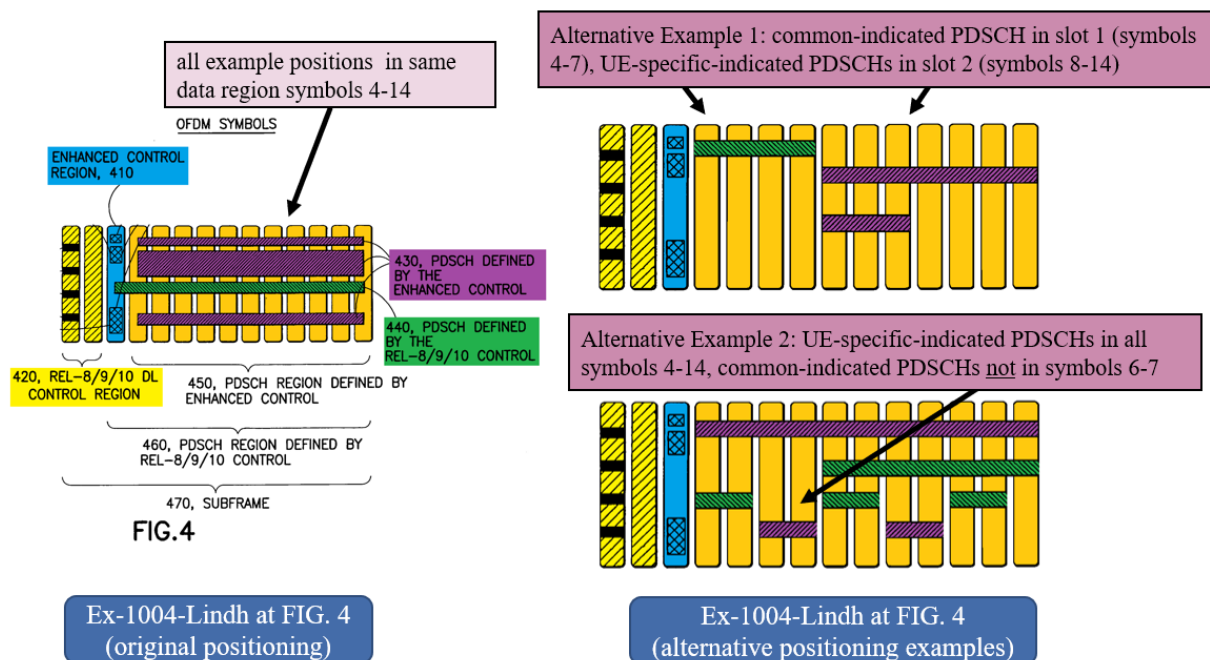


Figure 12 *Lindh indicates that the locations of PDSCH 430 and 440 are illustrative rather than limiting and therefore the positioning of common-indicated PDSCH and UE specific-indicated PDSCH may vary in both the time and frequency domains. (Ex-1004-Lindh at FIG. 4)*

93. Tooher confirms that a POSITA’s interpretation of Lindh’s teachings reflects the capabilities of a UE in the relevant time frame. Specifically, Tooher discloses that data resources (a) can be allocated in a single symbol or can be as long as an entire subframe, (b) may start in different symbols, and (c) may be specified by legacy PDCCH or enhanced

EPDCCH control signals. (Ex-1007-Tooher at FIG. 5, [0078]-[0081], [0088]-[0097], [0102]-[0104], [0143], [0146]-[0152], [0155]-[0157]; Ex-1008-Tooher at FIG. 4, [0061]-[0076], [0093]-[0103].)

94. One of ordinary skill in the art would have been motivated and found it obvious to combine Lindh and Tooher.
95. Lindh and Tooher are analogous art in the same field of endeavor as the '658 patent. Both Lindh and Tooher relate to LTE/LTE-A network configurations. (Ex-1004-Lindh at [0090]; Ex-1007-Tooher at [0029]; Ex-1008-Tooher-PROV at [0021].) Tooher facilitates improvement in transmission efficiency, latency, channel capacity, and scheduling flexibility by varying transmission time interval ("TTI") durations based on factors including the amount and type of data to be transmitted. (Ex-1007-Tooher at [0003]-[0005], [0078]-[0080]; Ex-1008-Tooher-Prov at [0002], [0061]-[0063], [0073], [0076], [0104].)
96. One of ordinary skill in the art would have found such improvements beneficial to Lindh. Indeed, the two references are described in the context of LTE networks, such that Tooher's disclosures for improving transmission efficiency, latency, channel capacity, and scheduling flexibility would be expected to offer the same predictable improvements for Lindh's UEs. Tooher's ability to vary the starting location and symbol duration of a given data resource in a subframe would allow the network to more fully utilize available resources in a way that would improve Lindh in the above ways.
97. One of ordinary skill in the art would have expected to succeed in making this combination. Lindh and Tooher disclose closely related

teachings, are in the same field as the '658 patent, and relate to enhancements in 3GPP LTE networks. More specifically, one of ordinary skill in the art would have had no difficulty utilizing Tooher's teachings in Lindh's UEs because doing so would merely require implementing routine software and/or hardware enhancements that would allow Lindh's eNBs/UE to more efficiently communicate, as disclosed in Tooher (e.g., variable TTI duration and related channel signaling information).

B. Challenged Claims

98. Ground 1 addresses claims 11-24.

1. [11.0] A method for a User Equipment (UE), comprising:

99. Lindh teaches the preamble. In the Brief Description of the Drawings, FIG. 5 is portrayed as "...a flowchart of an exemplary method performed by a user equipment in accordance with an exemplary embodiment." (Ex-1004-Lindh at [0068].)

100. Figure 5 of Lindh discloses the "Exemplary UE behavior when reading the DL control channel structure." (Ex-1004-Lindh at [0103].)

2. [11.1] communicating with a network node in a cell via downlink and uplink transmissions, wherein the downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;

101. Lindh teaches this limitation. Lindh discloses communicating with a network node in a cell via downlink and uplink transmissions.

“In a cellular radio system like 3GPP LTE, the base station (BS) (also known as eNode-B or eNB) signals the time-frequency resources allocated to a terminal (UE). In LTE, the downlink and uplink resources are allocated in terms of resource blocks (RB).” (Ex-1004-Lindh at [0082].)

102. One of ordinary skill in the art would have understood that this excerpt discloses the first portion of limitation 11.1, as Lindh’s UEs communicate with a network node in a cell (base station (BS, ENode-B, or eNB) via downlink and uplink transmissions. (*See* Ex-1004-Lindh at [0090].)

103. Lindh also discloses “the downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols.”

104. Lindh’s FIG. 4 discloses a subframe structure:

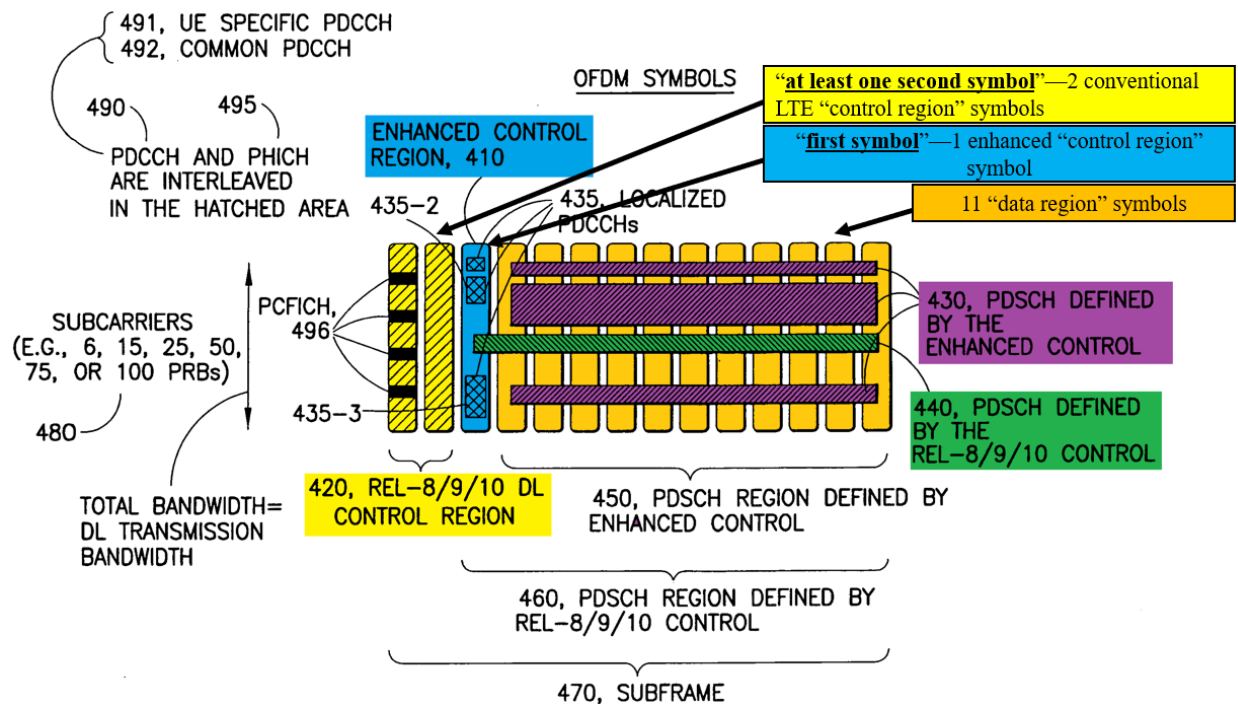


Figure 13 Lindh’s FIG. 4 illustrating the introduction of the enhanced downlink control channel within the three symbols devoted to the downlink control region. Note that the subframe is still composed of 14 symbols, 3 of which are devoted to the downlink control region and 11 of which are devoted to data. (Ex-1004-Lindh at FIG. 4.)

105. In regards to FIG. 4 Lindh explains:

“...the DL subframe **470** occupies in the time domain several OFDM symbols (of which there are 14 in this example). Thus, the DL subframe **470** has a time duration equivalent to the duration of 14 OFDM symbols in this example.” (Ex-1004-Lindh at [0102].)

106. Lindh FIG. 4 discloses a subframe of a frame structure, where the subframe is comprised of 14 symbols where 2 of the symbols are reserved for a conventional control region (420, highlighted by the Petitioner in yellow), 1 symbol is reserved for an enhanced control

region (410, highlighted by the Petitioner in blue), and 11 symbols are reserved for a data region (highlighted by the Petitioner in orange). One of ordinary skill in the art would understand that an LTE radio frame consists of subframes and each subframe contains 2 slots and each of those slots contains 7 symbols (in the normal cyclic prefix case), therefore each subframe contains $(2 \times 7) = 14$ symbols, just as described by the frame structure of Lindh in association with FIG. 4. Therefore, FIG. 4 of Lindh discloses an LTE radio frame used to organize the downlink transmissions.

107. Lindh also teaches that the uplink transmission was allocated in terms of resource blocks, and would also be organized by radio frames. (Ex-1004-Lindh at [0088].) Lindh does not illustrate an example of an uplink frame, but Lindh discloses that its network may be LTE/LTE-A (*id.* at [0090]) and incorporates-by-reference LTE/LTE-A specifications, including 3GPP TS 36.300 v8.11.0. (Ex-1004-Lindh at [0051].)
108. 3GPP-36.300 discloses that uplink/downlink frames are organized by subframes, slots, and symbols. (Ex-1011-3GPP-36.300-8.11.0 at §5 [pg. 23] (disclosing one 10ms frame organized into ten 1ms subframes, each subframe having one 0.5ms slot), §5.1 [pg. 25] (disclosing 7 OFDM symbols per slot when using “[n]ormal cycling prefix”), §5.2 [pgs. 27-28] (disclosing 7 SC-FDMA symbols per slot when using “[n]ormal cyclic prefix”).) Accordingly, a POSITA would have understood Lindh’s uplink frames would follow the same conventional organizational scheme.

109. One of ordinary skill in the art would have understood that the UE in Lindh communicated with eNBs in a cell via uplink and downlink frames that are organized into subframes, slots, and symbols, as these components are the same components of the resource block used to describe Lindh's transmissions.

110. Thus Lindh discloses this limitation.

3. [11.2] monitoring, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe,

111. Lindh discloses monitoring, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe.

112. In FIG. 5 Lindh provides a block diagram describing the UE behavior when reading the DL control channel structure (of a cell).

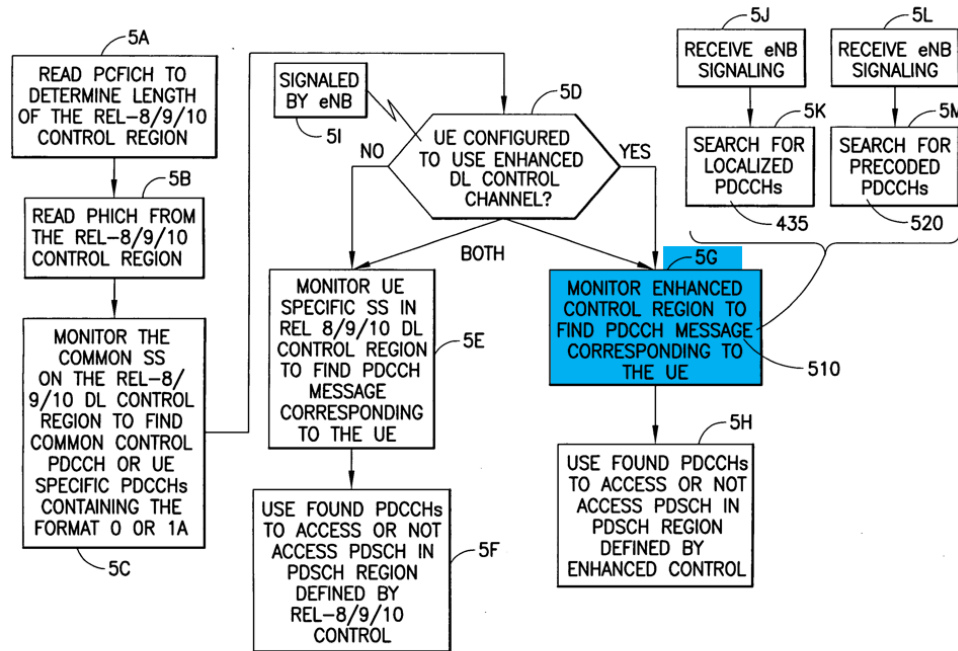


FIG.5

Figure 14 FIG. 5 of Lindh where Block 5E indicates the behavior of the UE in the cell when the UE is not configured for enhanced DL control channel, and 5G (highlighted in blue) indicates the behavior of the UE in the cell when the UE is configured for enhanced DL control. (Ex-1004-Lindh at FIG. 5)

113. The claimed “first symbol of a downlink control region” refers to the symbol corresponding to the enhanced control region 410 (highlighted in blue in FIG. 4).

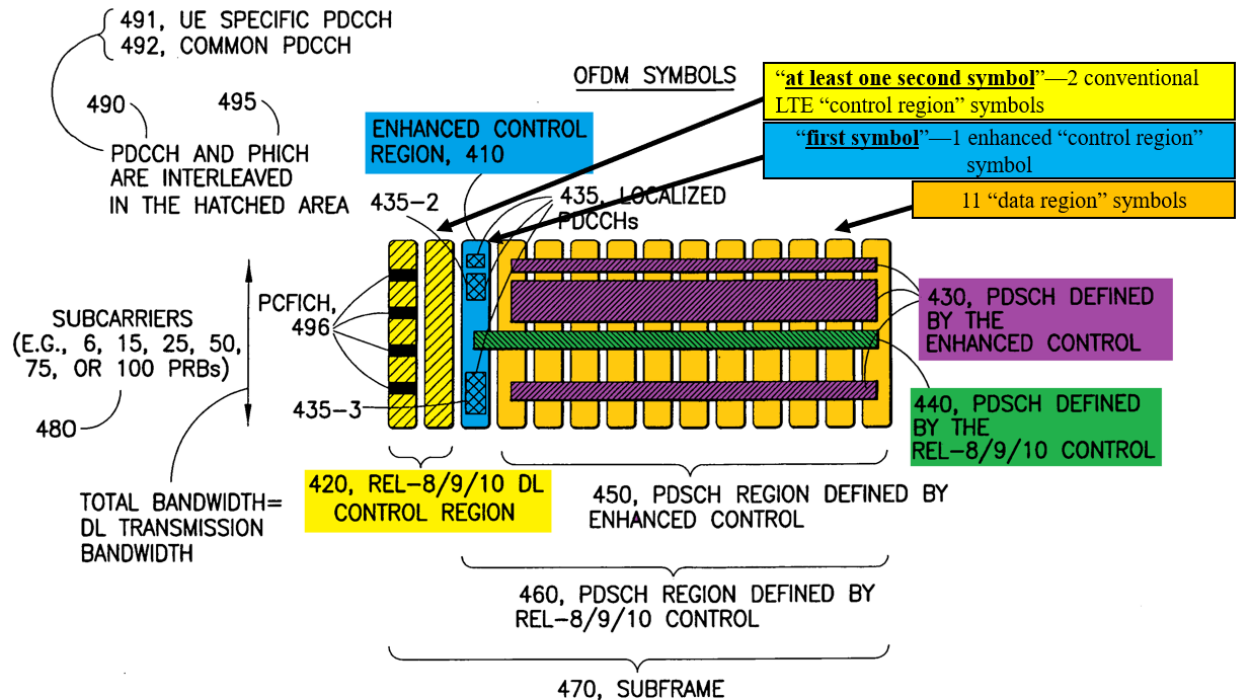


FIG. 4

Figure 15 The “first” symbol of the downlink control region is the symbol corresponding to the enhanced control region. (Ex-1004-Lindh at FIG. 4)

114. One of ordinary skill in the art would have understood that monitoring Lindh’s enhanced control region, per FIG. 5, to find a PDDCH message corresponding to the UE meant the UE was restricting its monitoring to UE specific signals (messages corresponding to the UE). This is described further in the context of FIG. 5, where in block 5G Lindh explains the behavior of the UE when the UE is configured to use the enhanced downlink control channel:

“...if the UE is configured to use the enhanced DL control channel (i.e., the accompanying enhanced control region **410**) (Block **5D=YES**), the UE monitors the enhanced control region **410** to find the PDCCHs **510** (and their messages) corresponding to the UE (e.g. PDCCHs **510** masked with its own C-RNTI or SPS-RNTI).” (Ex-1004-Lindh at [0108]; *see id.* at [0112]-[0129].)

115. Thus, one of ordinary skill in the art would have understood that by “monitor[ing](s) the enhanced control region 410 to find the PDCCHs 510 (and their messages) corresponding to the UE” the UE would be monitoring for a UE specific signal in at least one first symbol of a(n) (enhanced) downlink control region of a subframe.

116. Lindh teaches this limitation.

4. [11.3] and not monitoring a common signal in the at least one first symbol; and

[11.4] monitoring, in the cell, the common signal in at least one second symbol of the downlink control region,

117. Limitations [11.3] and [11.4] are addressed together as they relate to the symbol(s) in the downlink control region in which the common signals are (or are not) monitored.

118. Lindh teaches these limitations. FIG. 4 discloses two parts of a control region, the conventional control region (420, highlighted by the Petitioner in yellow) and the enhanced control region (410, highlighted by the Petitioner in blue).

119. Lindh indicates that the total downlink control region length is maintained when enhanced downlink control is introduced (e.g., the enhanced downlink control region, 410, is given one symbol and the legacy portion of the control region, 420, shrinks to two symbols). Moreover, when the enhanced downlink is configured, the UE specific

search space (and therefore where a UE monitors UE specific signals) are moved to the enhanced channel):

“No increase of the total DL control because the UE specific SS is moved to the enhanced channel for the Rel-11/12 UEs the Rel 8/9/10 control channel can be correspondingly decreased.” (Ex-1004-Lindh at [0124].)

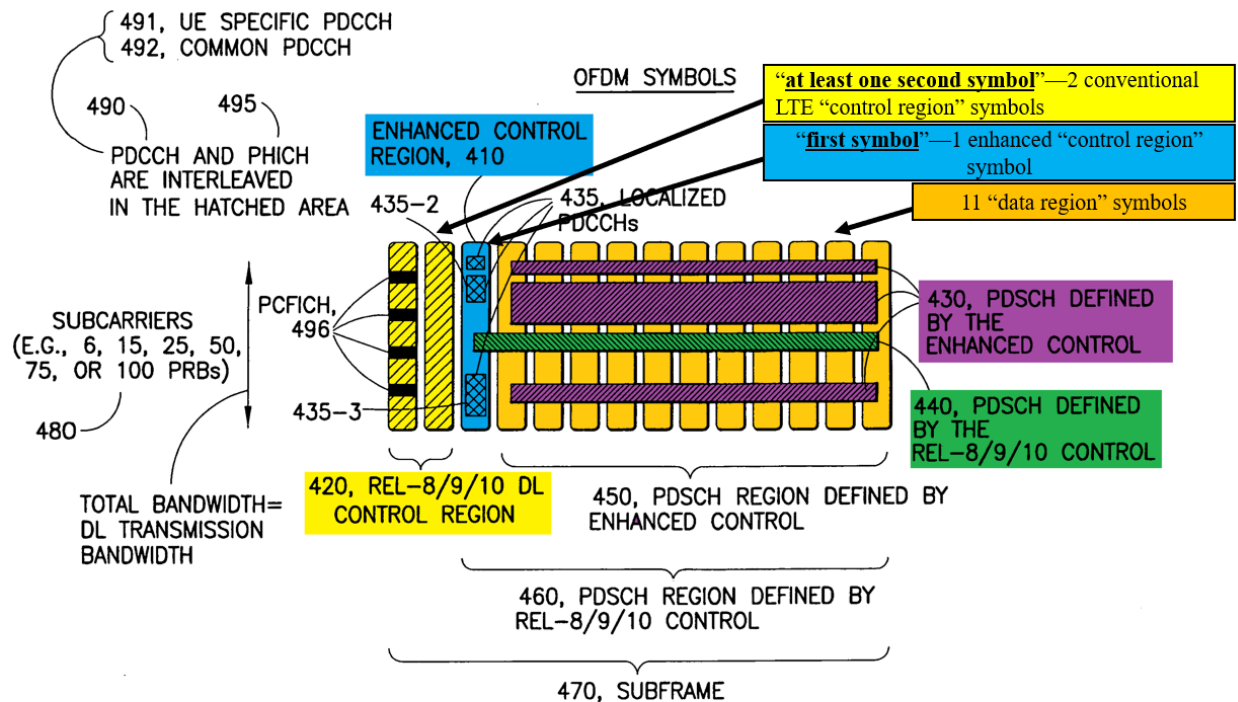


FIG. 4

Figure 16 Lindh’s LTE subframe contains a downlink control region that is made up of a conventional downlink control region (highlighted in yellow) and an enhanced control region (highlighted in blue). (Ex-1004-Lindh at FIG. 4.)

120. As a result, when the enhanced DL control is configured, an enhanced control region (410, highlighted by the Petitioner in blue) is the “first” symbol in which UE-specific signals are monitored. The conventional control region (420, highlighted by the Petitioner in yellow) in FIG. 4 has two “second” symbols, and a UE monitors these symbols for “a common signal.”

121. In FIG. 5 Lindh provides a block diagram describing the UE behavior when reading the DL control channel structure (of a cell).

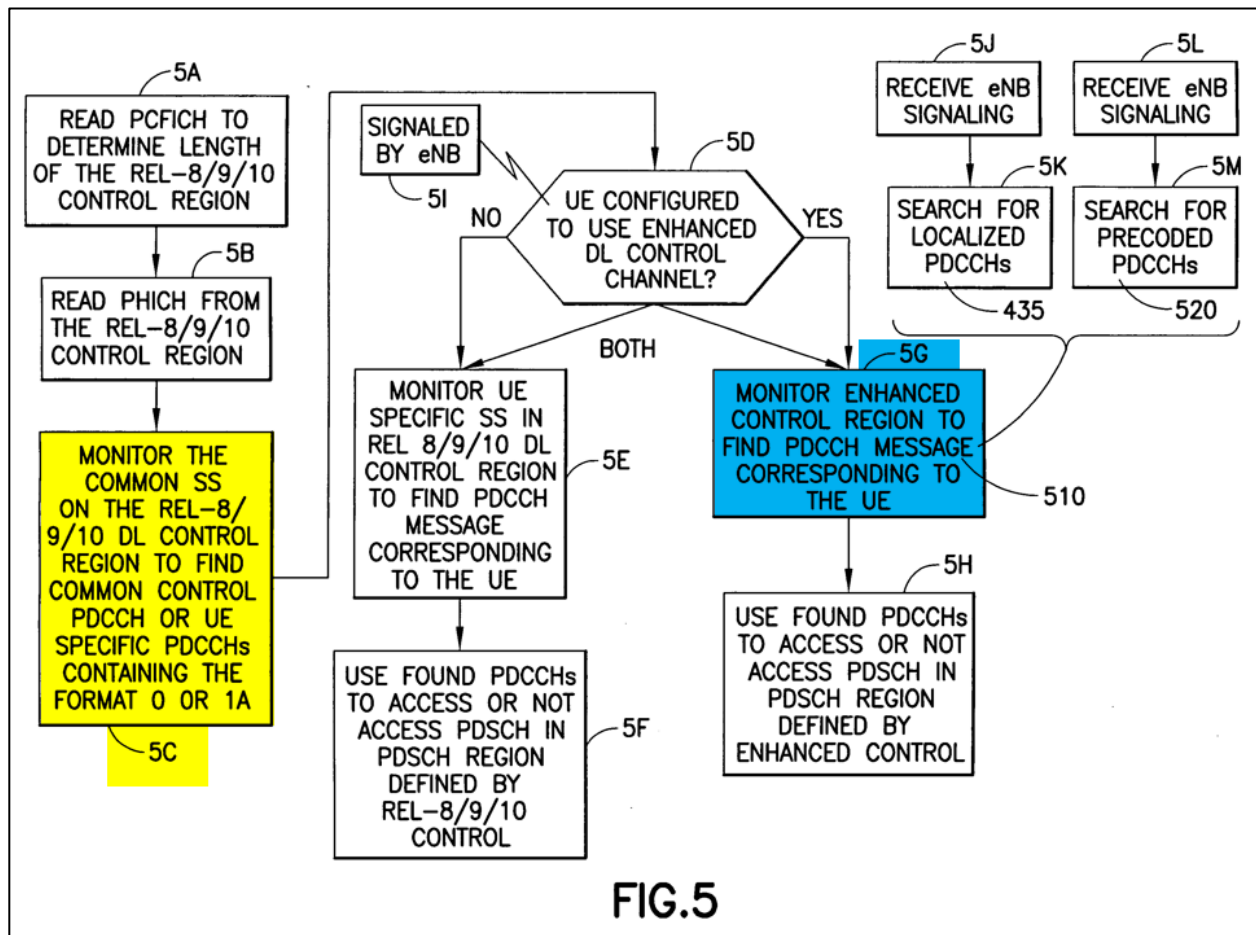


Figure 17 Lindh's FIG. 5 details how a common signal is monitored in the conventional downlink control channel (highlighted in yellow) while a UE specific signal is monitored in the enhanced control channel (highlighted in blue) when the UE is configured to use the enhanced DL control channel. (Ex-1004-Lindh at FIG. 5.)

122. In block 5C Lindh explains the behavior of the UE when the UE monitors the conventional downlink control channel 420 for common signals:

“In block 5C, the UE monitors the common SS on the Rel-8/9/10 type DL control region 420 in order to find the common PDDCH 492 which is recognized by having a CRC masked with SI-RNTI, RA-RNTI, or P-RNTI or UE specific PDDCHs containing the format 0 or 1A as explained in 3GPP TS36.213 Table 7.1-5.” (Ex-1004-Lindh at [0105].)

123. One of ordinary skill in the art would have understood that by “monitoring the common SS [search space] on the Rel-8/9/10 DL control region 420 in order to find the common PDDCH” the UE would be monitoring for a common signal in the conventional downlink control region 420 of a subframe. Thus, Lindh discloses monitoring a common signal in the “second” symbols of the downlink control region.

124. Moreover, when enhanced downlink control 410 is used, the “first” symbol is used to monitor for a UE specific signal and not a common signal, as laid out in block 5G of Lindh:

“In block 5G, if the UE is configured to use the enhanced DL control channel (i.e. the accompanying enhanced control region 410) (block 5D=YES), the UE monitors the enhanced control region 410 to find the PDCCHs 510 (and their messages) corresponding to the UE (e.g. PDCCHs 510 masked with its own C-RNTI or SPS-RNTI)...” (Ex-1004-Lindh at [0108].)

125. The same point is confirmed with respect to step 5C in FIG. 5. In particular, step 5C indicates that in some embodiments UE-specific signals may be monitored in the yellow control region—Lindh never discloses the inverse scenario, i.e., Lindh never discloses monitoring common signals in the blue enhanced control region.

126. Accordingly, one of ordinary skill in the art would have understood that the UE restricts its monitoring in the enhanced control region 410 to UE-specific symbols.

127. FIG. 4 also states “PDCCH AND PHICH ARE INTERLEAVED *IN THE HATCHED AREAS*,” which Lindh explains as being only applicable to the first two OFDM symbols:

“The hatched portions (*in this example two OFDM symbols*) of the subframe 400 denote the Rel-8/9/10 DL control region 420 and include the Rel. 8/9/10 PDCCH 490 (including UE specific Rel. 8/9/10 PDCCH 491 and common PDCCH 492), the PCFICH 496 and the PHICH 495.” (Ex-1004-Lindh at 0102.)

128. A POSITA would therefore know and expect that the common signal would only be monitored in the control region (420) of Lindh. As noted above, Lindh does not disclose or suggest that common signals (e.g., common PDCCH 492 in the excerpt above) were monitored in enhanced control region of (410). Thus Lindh teaches these limitations.

5. [11.5] wherein the common signal and the UE specific signal indicate resources in different symbols of the data region of the subframe.

129. This limitation at least encompasses resources in a data region that are not in coextensive symbols.

130. Lindh alone and in view of Tooher teaches this limitation.

131. Lindh’s FIG. 4 shows a data region of a subframe (470, highlighted by Petitioner in orange), having eleven OFDM symbols in which data channel (“PDSCH”) resources are transmitted. (Ex-1004-Lindh at [0084] (“...the data channel (PDSCH)”), [0089].) One of ordinary skill in the art would have understood the symbols highlighted in orange by the Petitioner in FIG. 4 are the symbols corresponding to the “data

region.” This is consistent with how the ’658 patent describes the data related portion of its frame structure with regards to PDSCH:

“As for downlink data in LTE, it is transmitted on PDSCH and carried by symbols excluding the first or first several symbols of a subframe, i.e. excluding the symbols which are (maybe) occupied by the physical control channels....” (Ex-1001 at 12:33-36.)

132. In FIG. 4 of Lindh, the downlink subframe features a “control region” where the control channels PDCCH, PCFICH, PHICH are transmitted. The “control region” is further delineated into conventional (rel-8/9/10) DL control region (highlighted by the Petitioner in yellow) and enhanced control region (highlighted by the Petitioner in blue). (Ex-1004-Lindh at [0101].)
133. Thus, Lindh discloses a separate downlink control region and data region.

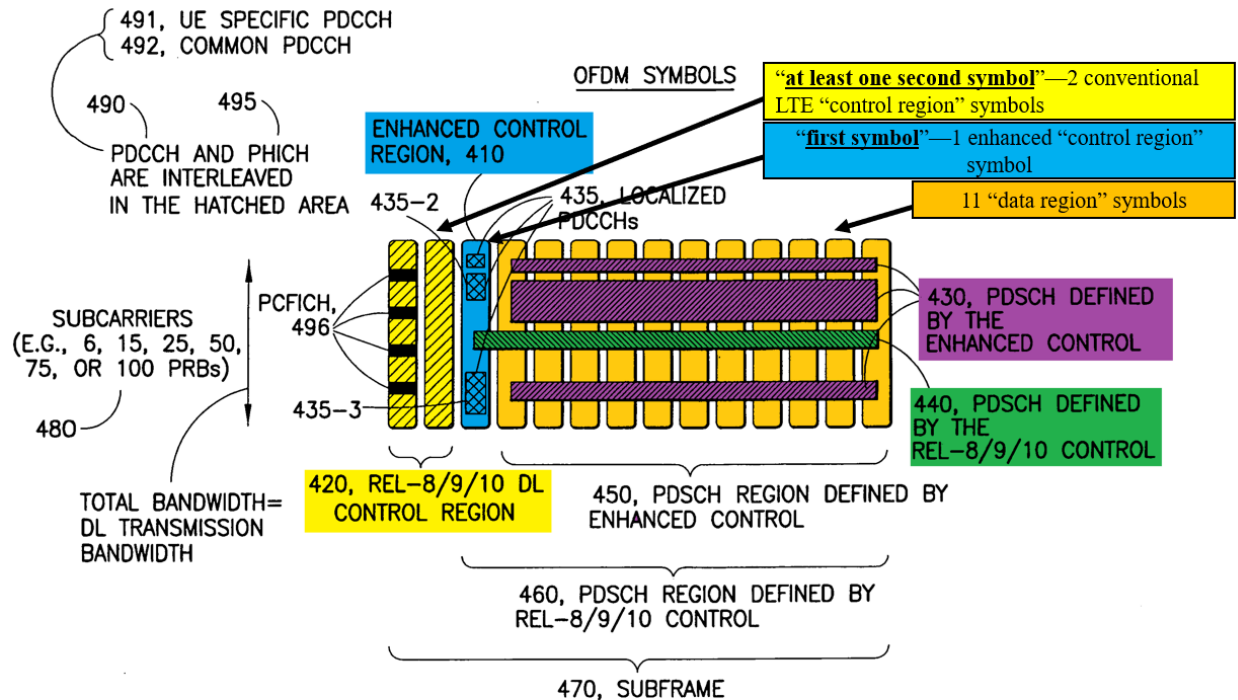


FIG. 4

Figure 18 *FIG. 4 of Lindh indicates a data region (highlighted by the Petitioner in orange) and a downlink control region comprised of a conventional DL control region (highlighted by the Petitioner in yellow) and an enhanced DL control region (highlighted by the Petitioner in blue). (Ex-1004-Lindh at FIG. 4 and [0089].)*

134. With respect to “indicat[ing] resources in different symbols of the data region of the subframe,” Lindh discloses that both types of signals (UE-specific and common) may indicate resources in the data region.

135. The examples in FIG. 4 show PDSCH resources that span the entire data region (the 4th data region symbol through the 14th data region symbol in FIG. 4 above). The horizontal bar highlighted green by the Petitioner in FIG. 4 (labeled 440) is associated with the common signals of the conventional control region 420 while the horizontal bars highlighted purple by the Petitioner in FIG. 4 (labeled 430) are associated with the UE specific signals of the enhanced downlink

control region 410. (Ex-1004-Lindh at FIGs. 4-5, [0084], [0100]-[0106], [0110]-[0112].)

136. Lindh further teaches that the positioning of those resources in the figure is merely an example: “the locations of the exemplary PDSCH 430 and 440 are merely illustrative and are not limiting.” (Ex-1004-Lindh at [0100].) Therefore, one of ordinary skill in the art would have understood that Lindh teaches common and UE-specific resources may be of any length and across different frequencies.
137. That is, resources indicated by UE-specific signals and common signals may occupy one data region symbol, eleven data region symbols, and all options in between, with varying degrees of symbol overlap for the UE-specific signaled and common-signaled resources in any given transmission.
138. Two non-limiting alternative examples (generated by the Petitioner) showing this teaching in the context of Lindh’s FIG. 4 are below:

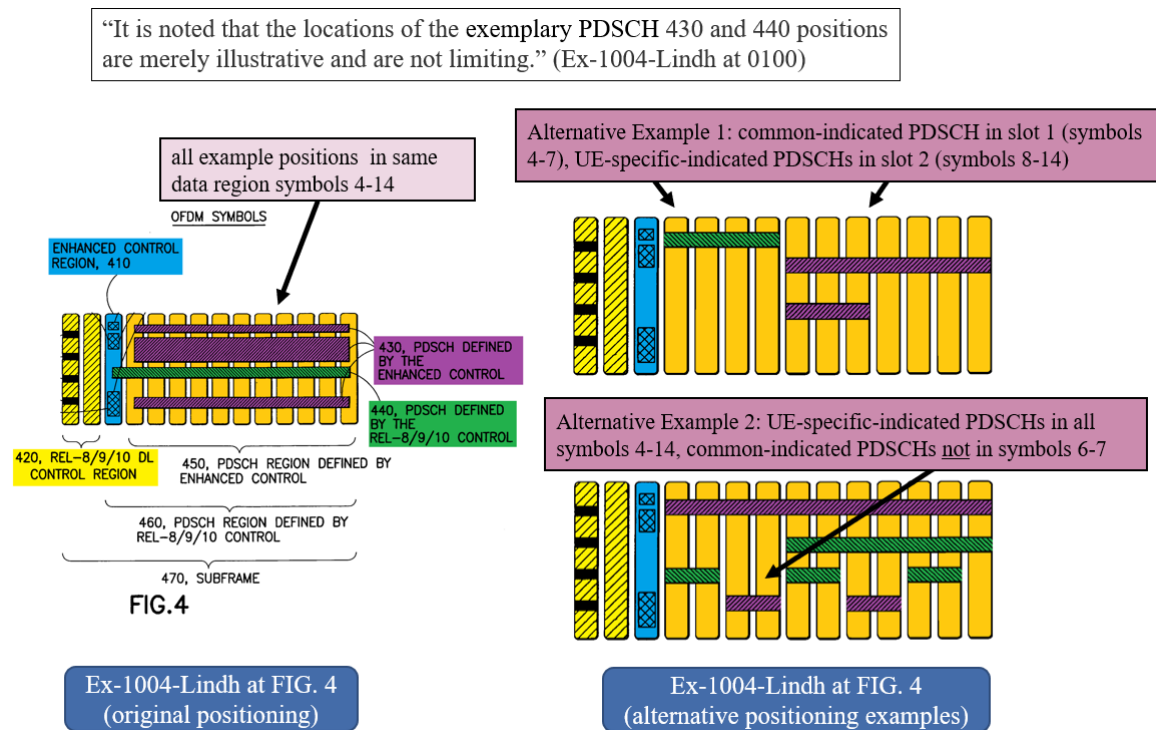


Figure 19 *Lindh’s FIG. 4 with the Petitioner’s alternative positioning of the common-indicated PDSCH and UE-specific indicated PDSCHs. (Ex-1004-Lindh at FIG. 4)*

Alternative Example 1 in the figure above shows how Lindh teaches and suggests resources in “completely different” symbols. It does so because UE-specific resource symbols do not overlap with common resource symbols at all. Alternative Example 2 also shows how Lindh teaches and suggests resources in (at least) “partially different” symbols. It does so by showing that there are UE-specific resources in symbols 6-7, but no “common” resources in symbols 6-7. Finally, under Patentee’s interpretation, Lindh’s FIG. 4 discloses “partially different” symbols as well, because data may be found in the green PDSCH region, which extends into symbol 3 where there would not be UE-specific resources.

139. In FIG. 5, Lindh further confirms that UE specific signals and common signals indicate resources in different symbols in the data region (PDSCH). For example, Lindh's UE uses information from step 5G (highlighted by the Petitioner in blue) to find resources in the data region ("PDSCH") defined by the enhanced control:

"In block 5H, the UE uses information from the found PDCCHs 510 to access or not access the PDSCH 430 in PDSCH region 450 defined by the enhanced control. In block 5H, the UE therefore determines portions of the PDSCH region 450 that correspond to the UE and contain at least some UE-specific information. Based on the information from the found UE Specific PDCCH messages UE also may not access the PDSCH region 450. That is, only if the PDCCH message contains a downlink assignment does the UE access the PDSCH region 450." (Ex-1004-Lindh at [0110].)

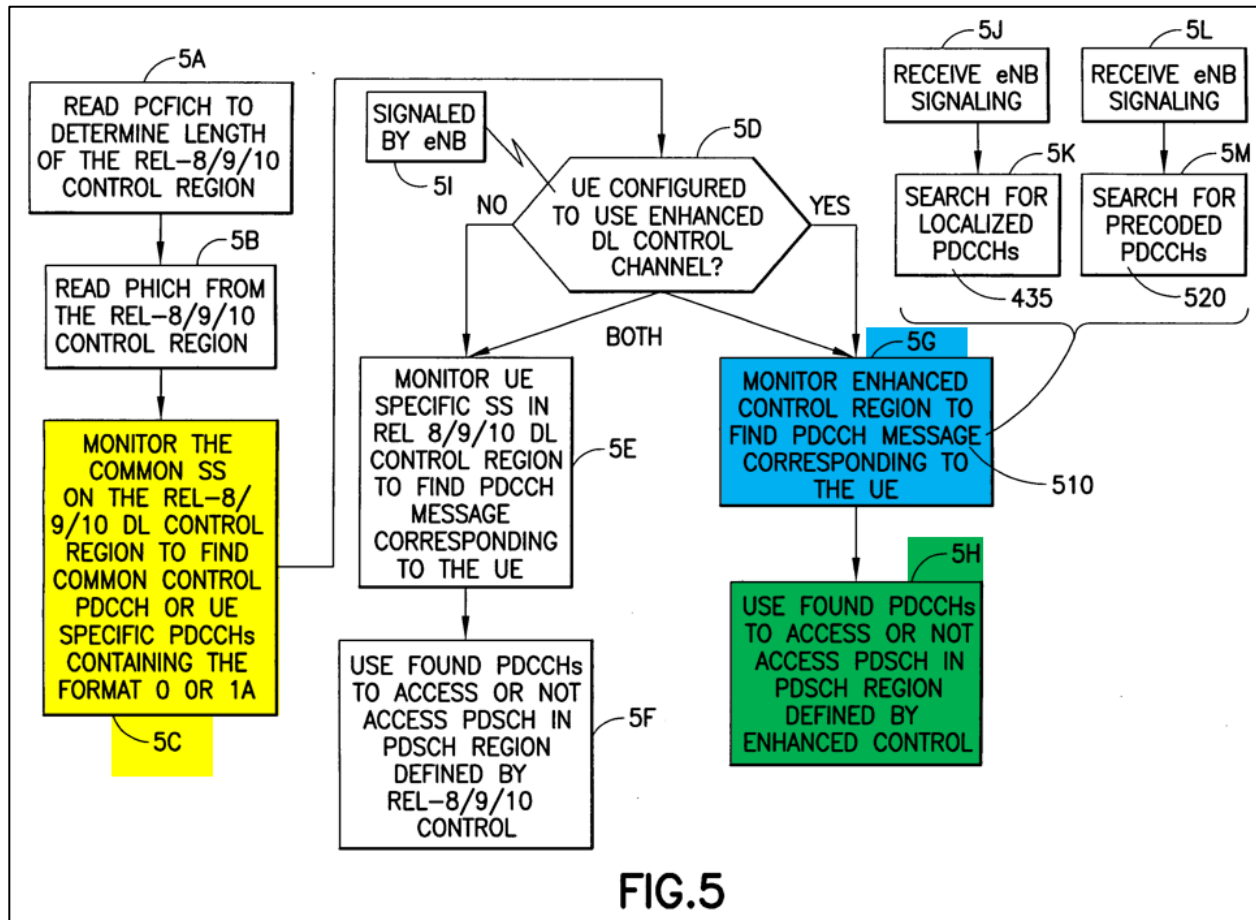


Figure 20 Lindh FIG. 5 block diagram discussing the UE's behavior when reading the DL control channel structure, indicates that when the UE finds a UE-Specific message on the Enhanced Control Region (see 5G, blue highlighted block) that UE specific message is used to indicate resources on the PDSCH (see 5H, green highlighted block.)

140. One of ordinary skill in the art would have understood that the UE in Lindh finds the UE specific signals in the enhanced control region 410 and then uses them to access the appropriate resources in corresponding PDSCHs in the data region, wherever they may be located. By specifically referring to “portions” of the data region in the above excerpt, one of ordinary skill in the art would have understood that Lindh confirms that different resources may be located in different symbols of the data region.

141. Limitation 11.5 is also disclosed by Lindh in view of Tooher. As detailed in §VII and §VIII.A, both Lindh and Tooher disclose LTE/LTE-A network configurations, and Tooher shows how to vary TTI durations in order to improve latency and enhance channel utilization.
142. Tooher discloses PDCCH and EPDCCH control signals that allocate resources in the PDSCH with varying duration from as little as one symbol up to an entire subframe. One of ordinary skill in the art would understand that Tooher is referring to the duration allocated to the transmission of a transport channel (including PDCCH, EPDCCH, and/or PDSCH) as the Transmission Time Interval (TTI). According to Tooher:
- “The TTI duration may be defined in terms of number of OFDM (Orthogonal Frequency Division Multiplexing) symbols. For example, a TTI duration may be defined as an entire subframe or a pair of resource blocks (PRBs or Physical Resource Blocks) (e.g. 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix). The TTI may be as short as a single OFDM symbol. The TTI duration may be defined as one or more time slots (e.g., 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). A combination of the above TTI durations can be used.” (Ex-1008-Tooher at [0080].)
143. In one example, Tooher discloses that control signals may indicate resources having variable lengths and starting positions.
144. Tooher’s FIG. 5 provides a specific illustration showing one EPDCCH control signal indicating a resource (“PDSCH assignment”) in a portion

of a data region in time slot 1, while a second EPDCCH control signal indicates a resource in slot 2:

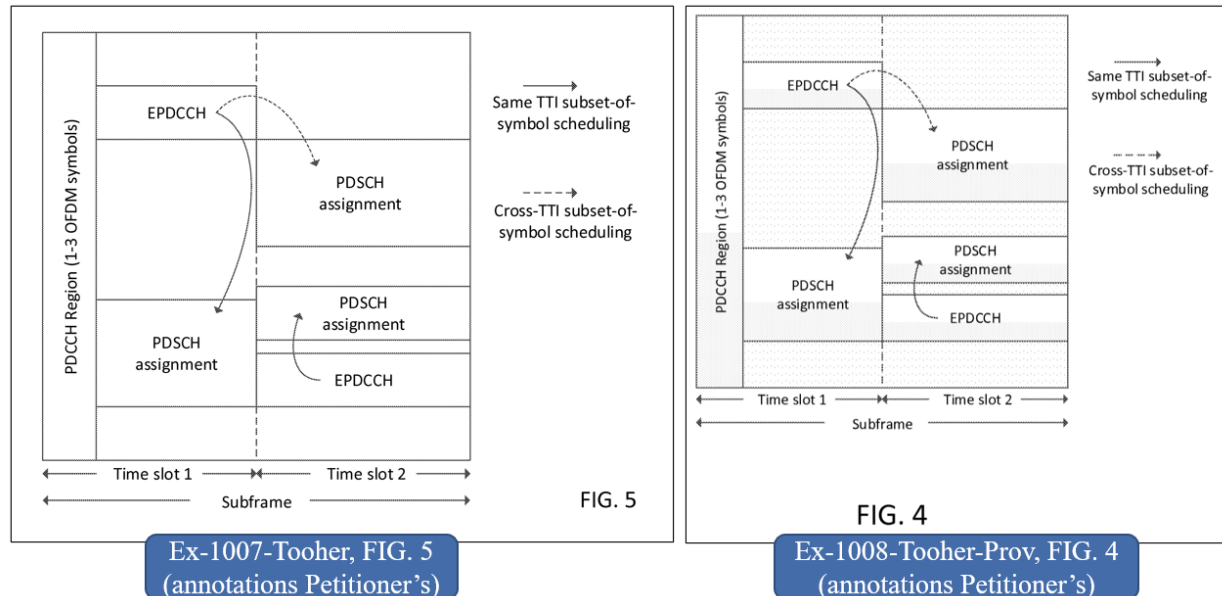


Figure 21 *FIG. 5 of Tooher illustrates EPDCCH with the same TTI duration as the resources it allocates, with the same or different location for transmission (time slot 1 or time slot 2).*

145. Tooher teaches that common signal and UE specific signals may indicate a variety of combinations of TTI durations (and therefore symbols of the data region) within the same subframe. In the specific example shown in FIG. 5, an EPDCCH indicates a resource allocation in symbols within the first time slot of the subframe for one signal, while another EPDCCH indicates a resource allocation in symbols within the second time slot of the subframe for a another signal. The time slots do not overlap, nor do the respective sets of symbols in each slot as Tooher utilized a conventional LTE radio frame.
146. One of ordinary skill in the art would understand that the two slots in a subframe do not overlap in time. (See, e.g., Ex-1006-Kim at FIGS. 1,

4; Ex-1001 at AAPA FIGS. 5-7.) Thus, when an EPDCCH allocates resources in a first time slot and another EPDCCH allocates resources in a second time slot in a subframe, it is understood that the symbols associated with the resource(s) in the first time slot and the symbols associated with the resource(s) in the second time slot are completely different.

147. Tooher further explains that signals in a PDCCH or EPDCCH may indicate resources in corresponding PDSCHs having variable durations and starting subframes, including the scenario where PDSCHs corresponding to an EPDCCH control signal are not the same length as PDSCHs corresponding to a PDCCH control signal:

“The shortened TTI may be applicable to a subset of channels (e.g., only to the subset), for example PDSCH. In such scenarios, among others, the control region (e.g., PDCCH, PCFICH, and/or PHICH) may use legacy TTI timing. The first shortened TTI’s PDSCH region may include the last X-C symbols of the TTI (e.g., where X may be the duration in symbols of the first shortened TTI and C may be the duration in symbols of the control region). The second TTI’s PDSCH region may be composed of one or more, or all, Y symbols (e.g., where Y may be the second shortened TTI’s duration).” (Ex-1007-Tooher at [0112]; *see* Ex-1008-Tooher-Prov at [0063]-[0064].)

“Scheduling of PDSCH assignments...using EPDCCH may require using the reuse of the same TTI duration for one or more, or each, channel, e.g., described by example with reference to FIG. 5. An EPDCCH located in a subset of symbols may assign...PDSCH...resources in the same subset of symbols, e.g., with a fixed time offset. Short TTI duration for EPDCCH may lead to short TTI duration for PDSCH.... The size and/or location of a TTI used for EPDCCH may be reused for PDSCH.... The TTI duration and/or location of the PDSCH...might not be tied to the TTI duration and/or location of the EPDCCH. For example, the EPDCCH may be located in a subset of symbols (e.g., a first time-slot); the assigned...PDSCH...resources may be for the entire subframe (e.g., full subframe TTI). The EPDCCH and/or PDSCH...may use reduced TTI duration. The EPDCCH may be located in (e.g., only in) a first subset of symbols. The EPDCCH in a first subset of symbols may assign...PDSCH...resources in a second subset of symbols. For example, an EPDCCH in a first time slot may assign...PDSCH...resources in a first time-slot and/or a second time-slot, e.g., in a cross-TTI scheduling manner.” (Ex-1007-Tooher at [0143] (references to UL transmissions and the corresponding PUSCH omitted); Ex-1008-Tooher-Prov at [0093]; *see also* Ex-1007-Tooher at [0146-152], [0155-0157]; Ex-1008-Tooher-Prov at [0094-0103].)

148. Different channels may also indicate resources that vary in length from a single symbol to subframe duration, such that common signals may indicate resources having different durations than UE-specific signals. (Ex-1007-Tooher at [0078]-[0081] (e.g., [0081] (“[A] TTI duration may be defined as an entire subframe or a pair of resource blocks (PRB or Physical Resource Blocks) (e.g., 14 OFDM symbols for normal cyclic prefix and 12 OFDM symbols for extended cyclic prefix). The TTI may be as short as a single OFDM symbol. The TTI duration may be defined as one or more time slots (e.g., 7 OFDM symbols for normal cyclic prefix and 6 OFDM symbols for extended cyclic prefix). A

combination of the above TTI durations can be used.”)), [0088], [0092]-[0093], [0102]-[0103]; Ex-1008-Tooher-Prov at [0061]-[0065] (describing the use of variable TTI durations from 1-symbol to subframe duration for various channels including EPDCCH, PDDCH, PUCCH, and PDSCH, e.g. [0064] (“[A] TTI duration may be defined as an entire subframe or a pair of [RBs] (e.g., 14 OFDM symbols....). The TTI may be as short as a single OFDM symbol. The TTI duration may be defined as a time slot (e.g., 7 OFDM symbols....). A combination of the above TTI durations may be used.”)), [0069]-[0070] (different channels may have different TTI durations, inclusive of the scenario where an “(E)PDCCH”¹⁶ is a different duration from its corresponding PDSCH), [0074]-[0076] (disclosing that a signal in a common search space may indicate a transmission of a first duration while a signal in a UE-specific search space may indicate a transmission of a second duration).) Thus, Tooher discloses that common and UE-specific signals in PDCCHs and EPDCCHs may indicate resources in “different” symbols under any reasonable interpretation because the resources indicated a corresponding PDSCH may be of any duration and located throughout the data region of a subframe.

149. One of ordinary skill in the art would have been motivated and found it obvious to apply the teachings of Tooher to Lindh, including as explained above in §VIII.A. This would have improved transmission efficiency, latency, channel capacity, and scheduling flexibility in Lindh’s network, as Tooher teaches. A POSITA would have expected

¹⁶“(E)PDCCH” refers to one or both of EPDCCH and PDCCH (i.e., “E” is optional).

to succeed in making this combination given the closely related teachings of Lindh and Tooher, which both relate to improved scheduling flexibility in 3GPP networks.

150. More specifically, a POSITA would have found it straightforward to apply Tooher's teachings to Lindh because doing so would merely require applying routine software and/or hardware updates to Lindh's UEs/eNBs to implement Tooher's downlink frame teachings.

151. Thus Lindh and Lindh in view of Tooher teaches this limitation, and Lindh in view of Tooher renders obvious claim 11.

6. [Claim 12] The method of claim 11, wherein the common signal and the UE specific signal indicate resources in completely different or partially different symbols of the data region of the subframe.

152. As explained above, Lindh in view of Tooher discloses resources in different symbols—as discussed above, the resources could be in completely different symbols or partially different symbols in view of Lindh alone and Lindh in view Tooher. Thus, Lindh in view of Tooher renders obvious claim 12 for the reasons discussed above relative to claim 11.

7. [Claim 13] The method of claim 11, wherein the UE monitors the UE specific signal in the second symbol.

153. Lindh discloses this limitation. Lindh describes the UE behavior where the UE-specific signal is monitored in both the enhanced DL control region (410, highlighted by the Petitioner in blue, “first symbol”) and the conventional control region (420, highlighted by the Petitioner in yellow, “second symbol”):

“In addition, as described above, advanced schemes could be envisioned, where the UE monitors the UE specific SS on both the Rel-8/9/10 type control channel (e.g., Rel-8/9/10 DL control region **420**) as well as on the enhanced DL control channel (e.g. enhanced DL control region **410**). That is the UE could perform the blocks 5G and 5H and also blocks 5E and 5F (block 5D=BOTH).” (Ex-1004-Lindh at [0111]; *see also id.* at [0112] FIGS. 4-5.)

154. One of ordinary skill in the art would have understood that the “advanced scheme” identified above involves monitoring UE-specific signals in the “first” and “second” symbols, i.e., in both the blue and yellow regions of Lindh’s FIG. 4 (reproduced relative to the next claim, below).

155. Thus Lindh discloses this limitation and Lindh in view of Tooher renders obvious claim 13.

8. [Claim 14] The method of claim 11, wherein the UE does not monitor the UE specific signal in the at least one second symbol.

156. Lindh discloses this limitation.

157. As discussed above regarding claim 13, Lindh’s disclosure of a UE that monitors the UE-specific signal in both the first (limitation 11.2) and second (claim 13) symbols is an “advanced scheme.” (Ex-1004-Lindh

at [0111], *see id.* at [0112], [0129].) Accordingly, one of ordinary skill in the art would have understood that Lindh's default operation was for UEs to monitor UE-specific signals in only the enhanced control region (410, highlighted blue by the Petitioner) in the "first symbol" without also monitoring them in the conventional control region (420, highlighted yellow by the Petitioner) in the "second symbol".

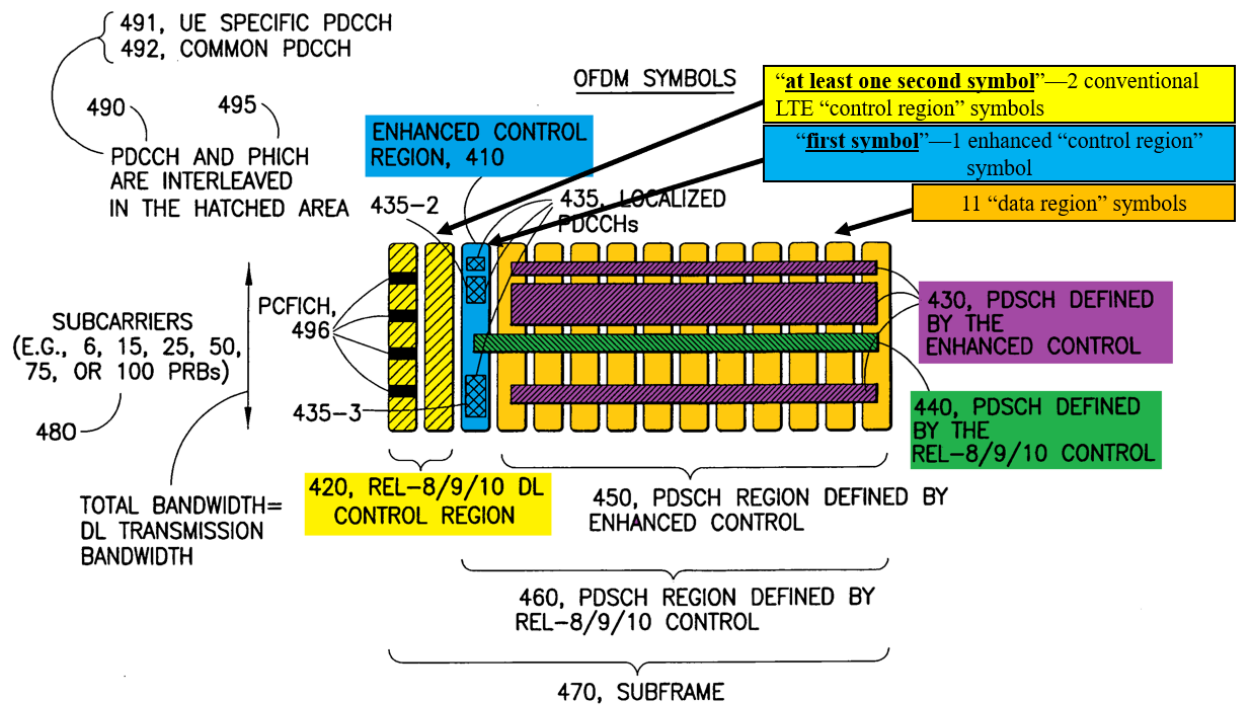


FIG. 4

Figure 22 FIG. 4 of Lindh illustrating that the conventional control region (420, highlighted by the Petitioner in yellow) is in the "second symbol" while the enhanced control region (410, highlighted by the Petitioner in blue) is in the "first symbol" (Ex-1004-Lindh at FIG. 4.)

158. Thus Lindh teaches this limitation, and Lindh in view of Tooher renders claim 14 obvious.

- 9. [Claim 15] The method of claim 11, wherein the UE specific signal is signaling indicating resource allocation, a signaling indicating HARQ (Hybrid Automatic Repeat request) feedback, and/or a reference signal for demodulation.**

159. Lindh teaches this limitation. Specifically, Lindh discloses:

“In block 5G, if the UE is configured to use the enhanced DL control channel (i.e., the accompanying enhanced control region 410) (block 5D=YES), the UE monitors the enhanced control region 410 to find the PDCCHs 510 (and their messages) corresponding to the UE (e.g. PDCCHs 510 masked with its own C-RNTI or SPS-RNTI).” (Ex-1004-Lindh at [0108].)

“In block 5H, the UE uses information from the found PDCCHs 510 to access or not access the PDSCH 430 in the PDSCH region 450 defined by enhanced control. In block 5H, the UE therefore determines portions of the PDSCH region 450 that correspond to the UE and contain at least some UE-specific information. Based on the information from the found UE specific PDCCH messages UE may also not access the PDSCH region 450. That is, only if the PDCCH message contains a downlink assignment does the UE access the PDSCH region 450.” (Ex-1004-Lindh at [0110].)

160. Accordingly, Lindh’s UE-specific signaling indicates at least resource allocations because Lindh’s UE determines from the UE-specific signal which resources are allocated to it, then accesses the allocated resource in the indicated part of the data region (PDSCH region 450).

161. Thus Lindh teaches this limitation and Lindh in view of Tooher renders obvious claim 15.

10.[Claim 16] The method of claim 11, wherein the common signal is a signaling indicating a system frame number (SFN), a signaling indicating resource allocation for a broadcast message, a syndication signal, or a reference signal for DL radio condition measurement.

162. The '658 patent treats system information, paging, and random access responses as broadcast messages:

“[T]he common downlink control signaling (e.g. for multiple UEs) could include at least one of the following signals or signalings:...A signaling (e.g., on PDCCH) allocate resource for a broadcast message (e.g., system information, paging, random access response)...” (Ex-1001 at 16:39-46.)

163. Lindh also discloses a particular type of common signal without describing mundane details of the signal: “the UE monitors the common SS on the Rel-8/9/10 type DL control region 420 in order to find the common PDCCH 492, which is recognized by having a CRC masked with SI-RNTI....” (Ex-1004-Lindh at [0105].) “SI-RNTI” refers to a system information broadcast signal. As noted above, such signals are common signals indicating a “resource allocation for a broadcast message.”

164. Sesia confirms that understanding by explaining that a common “signalling” message indicates the resource blocks allocated to broadcast data. (Ex-1005-Sesia at pg. 238 [§9.2.2.2 Special Uses of the PDSCH].) Sesia is an LTE reference book that “provides a thorough, authoritative and complete tutorial of the LTE system” inclusive of LTE-Advanced. (Ex-1005-Sesia at pg. 29.) Sesia provides express details regarding how “special purpose” information was conventionally transmitted in LTE:

“One such use is for the broadcast system information (i.e. SIBs) that is not carried on the PBCH. The RBs used for broadcast data of this sort are indicated by signalling messages on the PDCCH in the same way as for other PDSCH data, except that the identity indicated on the PDCCH is not the identity of a specific UE but is, rather a designated broadcast identity known as the System Information Radio Network Temporary Identifier (SI-RNTI), which is fixed in the specifications (see Section 7.1 of [1]) and therefore known a priori to all UEs.” (Ex-1005-Sesia at p237-239 [§9.2.2.2 Special Uses of the PDSCH].)

165. Sesia thus confirms that SI-RNTI is a common signal being monitored in the conventional LTE control region (PDCCH) by all UEs, and which indicates PDSCH resource allocations “in the same way as for other PDSCH data.” Accordingly, Lindh’s use of SI-RNTI broadcast signals indicates resource allocation for a broadcast message.
166. Thus, Lindh discloses this limitation, and Lindh in view of Tooher renders obvious claim 16.

11.[Claim 17] The method of claim 11, wherein a length of the downlink control region is two symbols and the UE does not monitor the UE specific signal in the at least second symbol.

167. This claim requires a downlink control region having exactly two symbols as discussed in §VI.
168. Lindh teaches a control region that is exactly two symbols and in which the UE-specific signal is not monitored in the “second symbol”.

169. The length of the downlink control region in Lindh (and in LTE) is indicated by the PCFICH channel, and is 1-3 symbols (or 2-4 symbols for smaller bandwidths):

“In LTE, the downlink control channel region, also shown in FIG. 2 as the DL control region, is transmitted in the first symbols of the subframe and the data channel (PDSCH) in the subsequent symbols as described in 3GPP TS 36.211, 3GPP TS 36.212, and 3GPP TS 36.213. There are three different channels involved in the DL control signaling:

- 1) PCFICH, which indicates the number of OFDM symbols for the DL control region (1-3 or 2-4 symbols for the smallest bandwidth)...” (Ex-1004-Lindh at [0084]-[0085].)

170. Block 5A of FIG. 5 in Lindh discloses that the PCFICH is read by the UE to determine the length of the DL control channel:

“In block 5A, the UE reads the PCFICH **496** to find the length of the Rel-8/9/10 type control channel, which is shown in the example of FIG. 5 as the Rel-8/9/10 DL control region 420. In this example, the length of Rel-8/9/10 DL control region 420 is two OFDM symbols in the time domain...” (Ex-1004-Lindh at [0104].)

171. In this excerpt, Lindh indicates that the conventional DL control region is two symbols long. When a UE is configured for enhanced DL control, the DL control region comprises the conventional DL control region 420 and the enhanced DL control region 410. Lindh proposed that the enhanced control channel could be transmitted in the next OFDM symbol(s) after the conventional DL control region. (Ex-1004-Lindh at [0095].) Thus as shown in FIG. 4 the downlink control region is 3 symbols long, two of which are in the conventional control region (420, yellow) and one of which is in the enhanced control region (410,

blue). Since Lindh expressly discloses that a downlink control region may have a shorter duration (e.g., 1 or 2 total symbols) and Lindh requires an enhanced control region 410, it would have been obvious to one of ordinary skill in the art to have a first symbol relating to the enhanced control region 410 and a second symbol relating to the conventional control region 420.

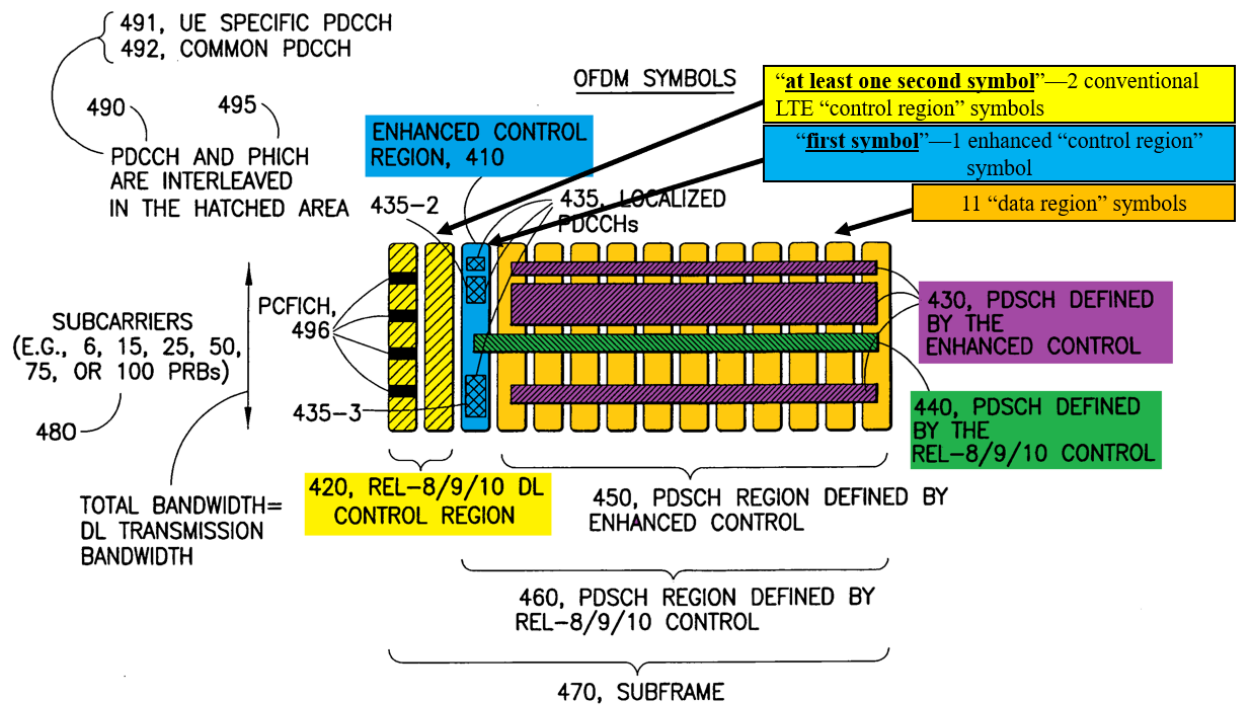


FIG. 4

Figure 23 FIG. 4 of Lindh illustrates that the downlink control region is comprised of 3 symbols, 2 symbols devoted to conventional downlink control (highlighted in yellow) and one symbol devoted to enhanced downlink control, though one of ordinary skill in the art would have understood that conventional and enhanced downlink control regions could each be on one symbol. (Ex-1004-Lindh at FIG. 4.)

172. The remainder of the claim is taught by Lindh for the reasons stated above relative to claim 14, and Lindh in view of Tooher renders obvious claim 17.

12.[18.0] A User Equipment (UE) for communication with a network node, comprising:

173. Lindh teaches this preamble for the reasons provided above regarding 11.0.

13.[18.0.1] a control circuit; [18.0.2] a processor installed in the control circuit; and [18.0.3] a memory installed in the control circuit and operatively coupled to the processor; [18.0.4] wherein the processor is configured to execute a program code stored in the memory to:

174. Lindh teaches these limitations. For example, Lindh discloses that its enhanced techniques may be implemented on a UE:

“Each UE 10 includes a controller, such as a computer or data processor (DP) 10A, a computer-readable memory medium embodied as a memory (MEM) 10B that stores a program of computer instructions (PROG) 10C, and at least one suitable radio frequency (RF) transceiver 10D for bidirectional wireless communications with the eNB 12 via one or more antennas 10 E.... The techniques herein may be considered as being implemented...as a combination of the computer program code (executed by one or more processors) and various hardware, including memory locations, data processors, buffers, interfaces and the like, or entirely in hardware (such as in a very large scale integrated circuit). Additionally, the transceivers 10D and 12D may also be implemented using any type of wireless communications interface suitable to the local technical environment, for example, they may be implemented using individual transmitters, receivers, transceivers, or a combination of such components.” (Ex-1004-Lindh at [0092], Abstract.)

175. One of ordinary skill in the art would understand that “a computer-readable memory medium embodied as a memory (MEM) 10B that stores a program of computer instructions (PROG) 10C” indicates a memory that stores program code. One of ordinary skill in the art would have also understood that “a combination of the computer program

(executed by one or more processors) and various hardware, including memory locations, data processors, buffers, and interfaces, and the like” would indicate a processor configured to execute program code stored in the memory. Thus, Lindh discloses a processor and memory, operatively coupled together and installed in control circuitry to execute a program code in the memory to implement limitations 18.1-18.5 and claims 19-24.

176. Thus Lindh teaches these limitations.

14.[18.1] communicate with the network node in a cell via downlink and uplink transmissions, wherein the downlink and the uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;

177. Lindh teaches this limitation for the reasons provided above regarding limitation 11.1.

15.[18.2] monitor, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe,

178. Lindh teaches this limitation for the reasons provided above regarding limitation 11.2.

16.[18.3] and not monitoring a common signal in the at least one first symbol; and

179. Lindh teaches this limitation for the reasons provided above regarding limitation 11.3.

17.[18.4] monitor, in the cell, the common signal in at least one second symbol of the downlink control region,

180. Lindh teaches this limitation for the reasons provided above regarding limitation 11.4.

18.[18.5] wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.

181. Lindh in view of Tooher, teaches this limitation for the reasons provided above regarding limitation 11.5, and Lindh in view of Tooher renders obvious claim 18.

19. Claim 19-24

182. Claims 19-24 include the same limitations as claims 12-13, 15-17, and 14, respectively, and thus are obvious for the same reasons provided above relative to those claims.

IX. GROUND 2: KIM IN VIEW OF 3GPP-36.300 AND R1-112517

A. Scope and Content of the Prior Art

183. Ground 2 relies on Kim in view of 3GPP-36.300 (Ex-1009) and R1-112517 (Ex-1010).

184. Kim discloses a communications system “applied according to [3GPP]” LTE or LTE-A technical specifications (RS), releases 8 and 10,

respectively, with a particular focus on methods “for monitoring a downlink control channel.” (Ex-1006-Kim at [0026], [0008].)

FIG. 1

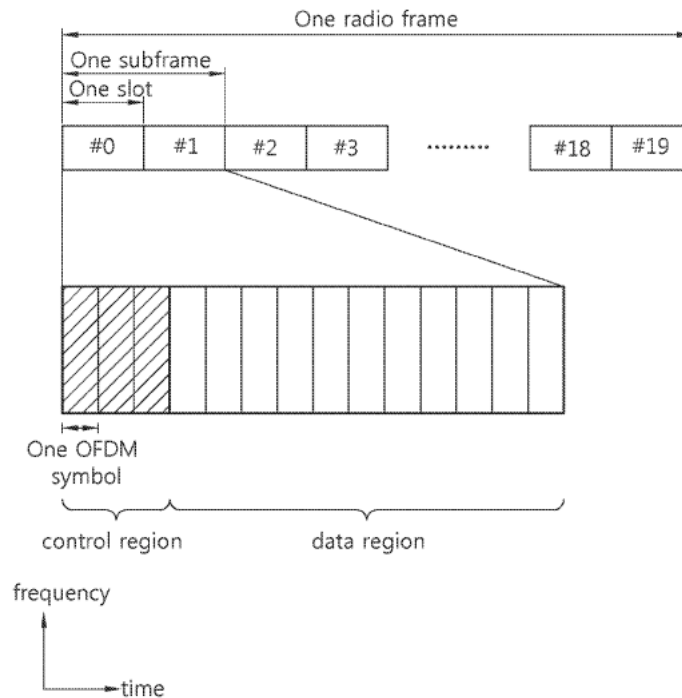


Figure 24 *FIG. 1 of Kim shows the conventional 3GPP LTE-A downlink radio frame (Ex-1006-Kim at FIG. 1.)*

185. With its downlink focus, Kim unsurprisingly omits the uplink frame structure that Kim’s UE would use. One of ordinary skill in the art would have reasonably expected Kim to use conventional 3GPP uplink frame organization.

“The wireless device may be served by a plurality of serving cells. Each serving cell may be defined with a downlink (DL) component carrier (CC) or a pair of a DL CC and an uplink (UL) CC.” (Ex-1006-Kim at [0027].)

186. One of ordinary skill in the art would have understood that the component carriers were used for uplink and downlink transmissions.

“The PHICH carries a positive acknowledgement (ACK)/negative-acknowledgement (NACK) signal for an uplink hybrid automatic repeat request (HARQ). The ACK/NACK signal for uplink (UL) data on a PUSCH transmitted by the wireless device is transmitted on the PHICH.

A physical broadcast channel (PBCH) is transmitted in first four OFDM symbols in a second slot of a first subframe of a radio frame. The PBCH carries system information necessary for communication between the wireless device and a BS. The system information transmitted through the PBCH is referred to as a master information block (MIB). In comparison thereto, system information transmitted on the PDCCH is referred to as a system information block (SIB).

Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI may include resource allocation of the PDSCH (this is referred to as a downlink (DL) grant, resource allocation of a PUSCH (that is referred to as an uplink (UL) grant), a set of transmit power control commands for individual UEs in any UE group and/or activation of a voice over Internet protocol (VoIP).” (Ex-1006-Kim at [0039]-[0041]).

187. One of ordinary skill in the art would have understood these excerpts describe the general use of uplink. Thus, Kim discloses uplink transmissions.
188. In 3GPP the conventional downlink transmissions are organized using OFDMA multiple access and conventional uplink transmissions are

organized using SC-FDMA multiple access. In particular, 3GPP-36.300 discloses that LTE (including Release 8, Release 10, and Release 12) uplink frames are organized into 10 subframes, 2 slots per subframe, and 7 SC-FDMA symbols per “normal” slot. (Ex-1009-3GPP-36.300 at §5.2; §VII.E.) One of ordinary skill in the art would have recognized that this was the obvious frame structure to use with Kim. Indeed, Kim’s FIG. 1 illustrates an LTE-A radio frame structure, and Kim generally defines a radio frame as having 10 subframes, with each having two slots. (Ex-1006-Kim at [0030]-[0031].) Kim also references LTE’s organization in which a slot comprises a plurality of OFDM symbol periods in the time domain for downlink frames, while noting that other symbols may be used as well.

“One slot may include a plurality of orthogonal frequency division multiplexing (OFDM) symbols in a time domain. Since the 3GPP LTE uses orthogonal frequency division multiple access (OFDMA) in a downlink (DL), the OFDM symbol is only for expressing one symbol period in the time domain, and there is no limitation in multiple access schemes or terminologies. For example, the OFDM symbol may also be referred to as another terminology such as a single carrier frequency division multiple access (SC-FDMA) symbol, a symbol period, etc.” (Ex-1006-Kim at [0032].)

189. Since Kim does not propose a modification to LTE’s uplink frame structure, one of ordinary skill in the art would expect Kim to use the conventional uplink frame organization whereby a frame is organized into subframes, subframes into slots, and slots into symbols (SC-FDMA symbols in the case of the conventional LTE uplink frame).

190. Kim also discloses “[a] control region of a subframe include[s] a plurality of control channel elements (CCEs).”¹⁷ (Ex-1006-Kim at [0051].) Kim discloses monitoring PDCCH candidates (defined in terms of “control channel elements” [“CCEs”]) and enhanced PDCCH (“EPDCCH”) candidates (defined in terms of enhanced CCEs [“ECCEs”]) in different portions of a subframe. (E.g., Ex-1006-Kim at [0096]-[0098].) Kim also discloses two different examples (FIGs. 4-5) in which different PDSCH elements (such as data resources that would be indicated by PDCCH or EPDCCH signals) occupy different symbols within a subframe:

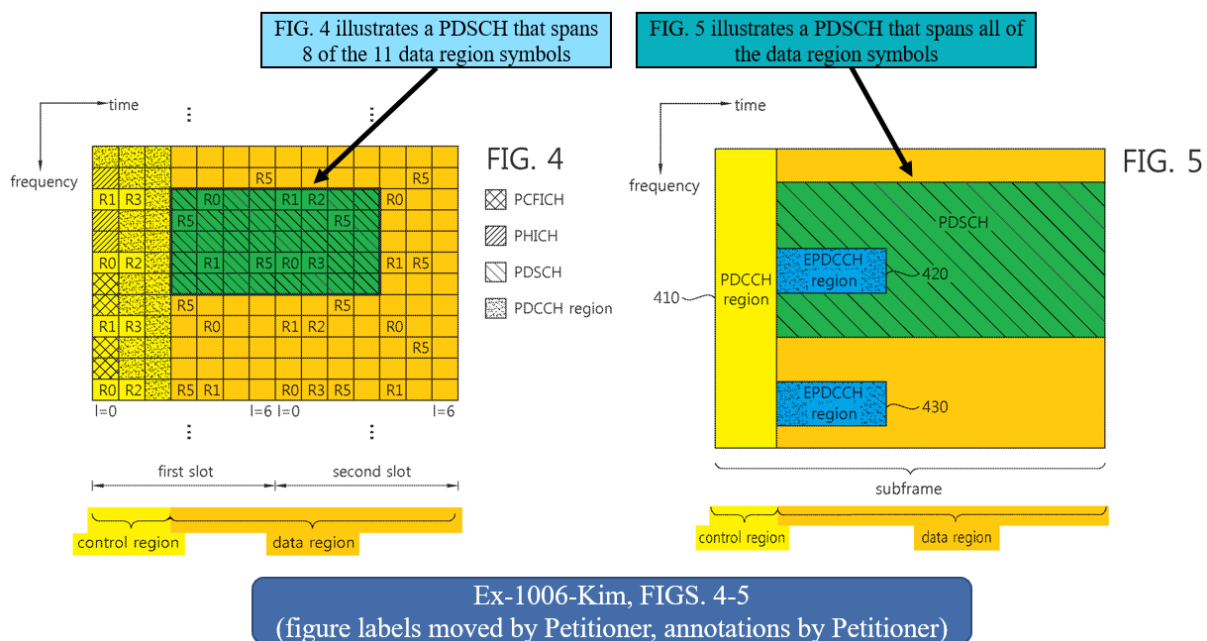


Figure 25 FIGS. 4 and 5 of Kim illustrate that different PDSCH elements occupy different symbols within a subframe (Ex-1006-Kim FIGS. 4-5 with figure labels moved by the Petitioner and annotations provided by the Petitioner.)

¹⁷ A “CCE is a logical allocation unit,” and “a wireless device having a good DL channel can use one CCE in PDCCH transmission.” (Ex-1006-Kim at [0051]-[0053] (noting that more CCEs may be used when needed).)

191. In FIG. 4 the PDSCH symbols span just 8 of the 11 data region symbols, whereas in FIG. 5 the PDSCH symbols span all 11 of the data region symbols. Kim does not explicitly indicate when data resources may occupy different symbols in the data region of the subframe.
192. A 2011 Samsung proposal discloses a way to “[e]xtend[] the capacity of the [downlink] control channel” by using the legacy PDSCH region for transmission of enhanced control information. (Ex-1010-R1-112517 at §1.) For example, in the subsection entitled “Enhanced DL Control Region Granularity and Multiplexing,” uses the term “eCCE” (like Kim) to refer to enhanced control channel elements. (Ex-1010-R1-112517 at §1.) R1-112517 discloses transmitting PDCCH signals in the

conventional control region symbols, while also transmitting EPDCCH signals in eCCEs in the conventional data region:

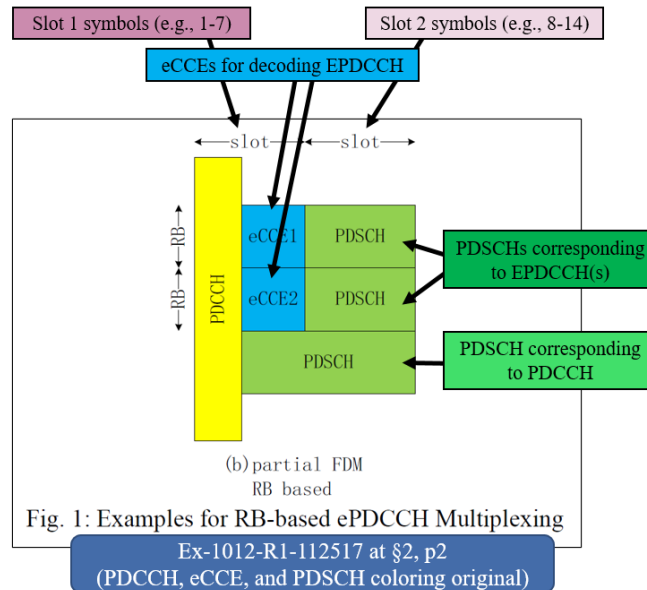


Figure 26 *Fig.1(b) of R1-112517 illustrates a LTE subframe with a PDCCH and its corresponding PDSCH and two EPDCCHs (signified by the eCCEs which are used to decode them) and the “e”PDSCH corresponding to these EPDCCH (Ex-1012-R1-112517 at §2, pg. 2.)¹⁸*

193. One of ordinary skill in the art would understand that Fig. 1(b) teaches a PDCCH (highlighted in yellow) indicating a PDSCH that occupies symbols in both slots (e.g., symbols 4-14 if the PDCCH spans 3 control region symbols). Meanwhile, the eCCEs are used to decode an EPDCCH (blue) in the first slot, which indicate resources in

¹⁸ Note: FIG 1(b) of R1-112517 shows the PDCCH allocating resources in all 11 symbols of the data region, while FIG 4 of Kim shows the PDCCH allocating resources in only 8 of the 11 symbols in the data region, one of ordinary skill in the art would understand that Kim and R1-112517 both disclose a PDCCH allocating resources in the PDSCH in the data region. The PDSCH associated with Kim could be 11 symbols but as shown in FIG. 4 data was only associated with 8 of those 11 symbols.

corresponding PDSCHs in the second slot (e.g., symbols 8-14). (Ex-1010-R1-112517 at §2.) One of ordinary skill in the art would have this understanding from the description of the figure, which states: “Such a design will also shorten the decoding time of an EPDCCH and PDSCH decoding can start from the second slot once a DL grant is detected.” (Ex-1010-R1-112517 at §2.) Indeed, this reflects known functionality in 3GPP LTE networks: by locating EPDCCH and PDCCH transmissions of a downlink subframe as early as possible in the subframe, decoding of corresponding downlink resources, like data resources indicated by a PDCCH or EPDCCH in a PDSCH, can begin more quickly. (*See, e.g.*, Ex-1017-Dahlman at 199-200.)¹⁹ Placing these downlink scheduling assignments at the beginning of a subframe permitted the process of demodulating and decoding of downlink data transmissions to begin before the end of the subframe, thereby reducing overall downlink transmission delay. (*Id.*) This was one reason why conventional subframes had a control region in the first few symbols of a subframe, followed by a data region. (*See, e.g., id.* at 199-200 & 422.)

194. One of ordinary skill in the art would have understood that by not only placing the eCCE toward the beginning of the subframe, but also shortening the eCCE’s duration to one slot in R1-112517 (as shown in Fig. 1(b)) the process of demodulating and decoding of the downlink data transmission associated with that eCCE would be able to begin earlier, thereby reducing the latency of downlink transmissions.

¹⁹ Ex-1017-Dahlman is the second edition of a textbook titled “4G LTE/LTE-Advanced for Mobile Broadband” by Erik Dahlman, Stefan Parkvall, and Johan Sköld. The second edition was published in 2013. (Ex-1017 at 6.)

195. Thus, R1-112517 would have taught and suggested to one of ordinary skill in the art that the upper two PDSCH regions that only appear in the second slot correspond to the eCCE elements that are in the left slot in the same horizontal position. With this downlink subframe structure, the UE can begin decoding the PDSCH data resources more quickly after decoding the corresponding eCCEs. Likewise, this subframe structure discloses a PDCCH may indicate resources in the data region that occupy all of the data region symbols (the bottom PDSCH occupies both slots in Fig. 1(b)), while the enhanced control transmitted in the eCCE portions of the subframe may indicate resources in just one portion of the data region (i.e., the second slot of the subframe).
196. One of ordinary skill in the art would have been motivated and found it obvious to utilize the eCCE scheme of Fig. 1(b) of R1-112517 with Kim. As R1-112517 shows, Kim's downlink subframe structure would be improved by permitting some data resources to be transmitted in just the second slot of the subframe rather than requiring both slots for PDSCH transmission. In this scenario, the common signals in the conventional downlink control region may indicate data resource allocations that occupy all of the data region symbols, while the UE specific signals (e.g., enhanced control signals) in the EPDCCH control region indicate data resources in slot 2 only. As R1-112517 recognizes, the scheme of Fig. 1(b) "will [] shorten the decoding time of an EPDCCH" with the additional benefit that "PDSCH decoding can start from the second slot once a DL grant is detected." One of ordinary skill in the art would have understood that having a shortened PDSCH decoding for EPDCCH signals would be beneficial to Kim as it would

enable more resource-efficient use of a subframe and reduce transmission delay by facilitating earlier decoding of data resources (e.g., PDSCH decoding may begin after the first slot of the subframe is received, without having to wait for the UE to receive the entire subframe).

197. Likewise, one of ordinary skill in the art would have succeeded in combining Kim with R1-112517's ability to transmit (and begin decoding) data resources that occupy only the symbols of a subframe corresponding to the subframe's second slot—in particular, enhanced control region symbols from the first slot would be decoded and used to locate indicated data resources in the second slot, where they could begin decoding more quickly than if the enhanced control region spanned both slots and the location of the data resources contained therein are not able to be known until the enhanced control region is completely received and decoded, i.e., at the end of a subframe. As noted above, this merely required applying conventional knowledge and technology in a predictable manner, i.e., by decoding a control signal from the first slot and using it to find corresponding data resources in the second slot in a known manner.

B. Challenged Claims

198. Ground 2 addresses claims 11-24.

1. [11.0] A method for a User Equipment (UE), comprising:

199. Kim teaches this preamble. Kim discloses “...a method of monitoring a downlink control channel and a wireless device using the method.” (Ex-1006-Kim at [0008].) Where the wireless device is a User Equipment (UE) “A wireless device may be fixed or mobile, and may be referred to as another terminology, such as a user equipment (UE)...” (Ex-1006-Kim at [0027].) Kim also discloses “the present invention is applied according to” 3GPP LTE or LTE-A, which define a communications network as having network nodes (BSs; eNBs) and user equipment (UE), and methods for the same. (Ex-1006-Kim at [0024]-[0026].)

200. Thus Kim teaches this preamble.

2. [11.1] communicating with a network node in a cell via downlink and uplink transmissions, wherein the downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;

201. Kim alone and in view of 3GPP-36.300 teaches this limitation.

202. Kim’s UEs communicate with a network node (base station/eNB) in a cell in an LTE network via downlink and uplink transmissions.

“A base station (BS) is generally a fixed station that communicates with the wireless device, and may be referred to as another terminology, such as evolved-NodeB (eNB), a base transceiver system (BTS), an access point, etc.

Hereinafter, it is described that the present invention is applied according to a 3rd generation partnership project (3GPP) long term evolution (LTE) based on 3GPP technical specification (TS) release 8 or 3GPP LTE-advanced (LTE-A) based on 3GPP TS release 10.

...LTE and/or LTE-A are collectively referred to as LTE. The wireless device may be served by a plurality of serving cells. Each serving cell may be defined with a downlink (DL) component carrier (CC) or a pair of DL CC and an uplink (UL) CC.” (Ex-1006-Kim at [0025]-[0027].)

203. One of ordinary skill in the art would understand that LTE is a network and a base station is a node within that network. One of ordinary skill in the art would also understand that a UE communicates with a serving cell via component carriers which carry uplink and downlink transmissions. Thus, Kim discloses “communicating with a network node in a cell via downlink and uplink transmissions.”

204. Further Kim illustrates that radio frames are subdivided into subframes and each subframe contains multiple symbols in FIG. 1:

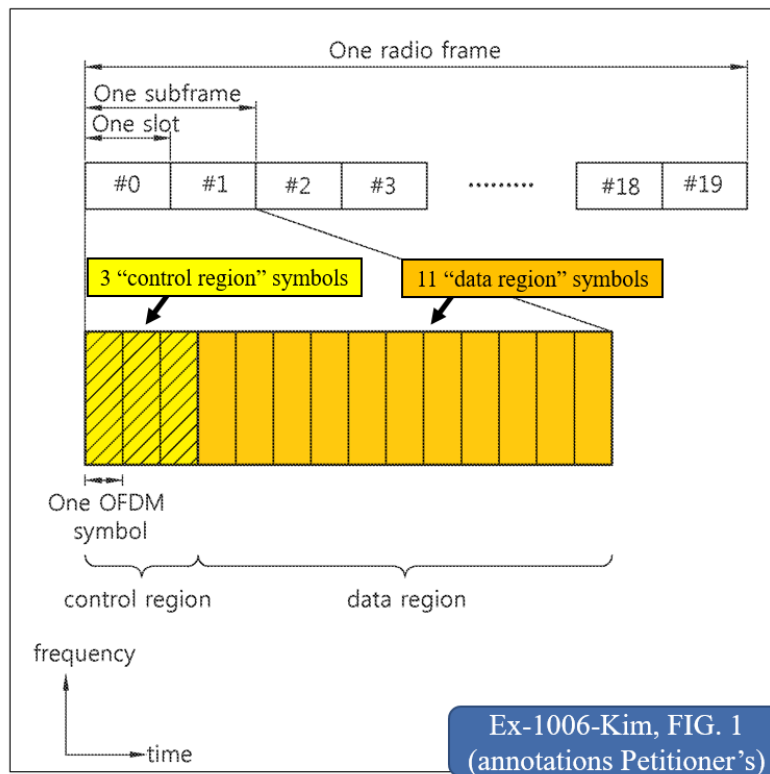


Figure 27 *Kim FIG. 1 describes a radio frame that is subdivided into multiple subframes and each subframe is further subdivided into multiple symbols (Ex-1006-Kim at FIG. 1.)*

205. In FIG. 1 Kim indicates each subframe contains 14 symbols. The first 3 symbols of a subframe are dedicated to a “control region” (highlighted by the Petitioner in yellow), while the remaining 11 symbols of a subframe are dedicated to a “data region” (highlighted by the Petitioner in orange). Kim discloses that downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe contains multiple symbols.

206. As it relates to the uplink radio frames, Kim refers the reader to 3GPP LTE technical specifications. (Ex-1006-Kim at [0026].) 3GPP-36.300 discloses that the uplink and downlink transmissions are organized in frames. For instance it indicates “[d]ownlink and uplink transmission are organized into radio frames with 10 ms duration” (Ex-1009-3GPP-36.300 at §5 [pg. 47].) 3GPP-36.300 also indicates that frames are divided into equally-sized subframes, with each subframe having two slots. (Ex-1009-3GPP-36.300 §5.2 [pg. 52].) In the uplink, in particular, 3GPP-36.300 discloses that normal LTE uplink slots have seven SC-FDMA symbols per slot, as was pointed out in the ’658 Patent:

“Frame structure in LTE, as discussed in 3GPP TS 36.300 is organized into radio frames and each radio frame (e.g. 10 ms) is divided into 10 subframes. Each subframe may include two slots.” (Ex-1001 at 5:18-25.)

207. In fact, both the ’658 Patent and Kim use the LTE frame structure from 3GPP-36.300. (Ex-1001 at 5:26-52; Ex-1006-Kim at [0030]-[0031]).

208. For Kim in particular:

“FIG. 1 shows a structure of a DL radio frame in 3GPP LTE-A. The section 5 of 3GPP TS 36.211 V10.2.0 (2011-06) “Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 10)” may be incorporated herein by reference. A radio frame includes 10 subframes indexed with 0 to 9. One subframe includes 2 consecutive slots. A time required for transmitting one subframe is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1 millisecond (ms), and one slot may have a length of 0.5 ms.” (Ex-1006-Kim at [0030]-[0031].)

209. One of ordinary skill in the art would have understood that the downlink in LTE is transmitted using orthogonal frequency division multiple

access (OFDMA) and the uplink in LTE is transmitted using single carrier frequency division multiple access (SC-FDMA). Therefore, one of ordinary skill in the art would have understood that the radio frame that Kim describes could contain OFDM or SC-FDMA symbols depending on whether it was used for the downlink or uplink respectively. (Ex-1009-3GPP-36.300 at §5 [page 47] (disclosing “[d]ownlink and uplink transmission are organized into radio frames with 10ms duration” and that frames are divided into equally-sized subframes, with each subframe having two slots), §5.2 [page 52] (disclosing that normal LTE uplink slots have seven SC-FDMA symbols per slot); Ex-1001 at 5:18-25 (admitting the same via citation to 3GPP-36.300); *see id.* at 5:26-52 (further describing LTE frame structure from 3GPP-36.300).)

210. Thus, Kim in view of 3GPP-36.300 teaches this limitation.

3. [11.2] monitoring, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe, [11.3] and not monitoring a common signal in the at least one first symbol; and [11.4] monitoring, in the cell, the common signal in at least one second symbol of the downlink control region,

211. Kim teaches these limitations. FIG. 5 illustrates Kim's pertinent disclosures at a high level; a more detailed explanation of each aspect of these limitations then follows.

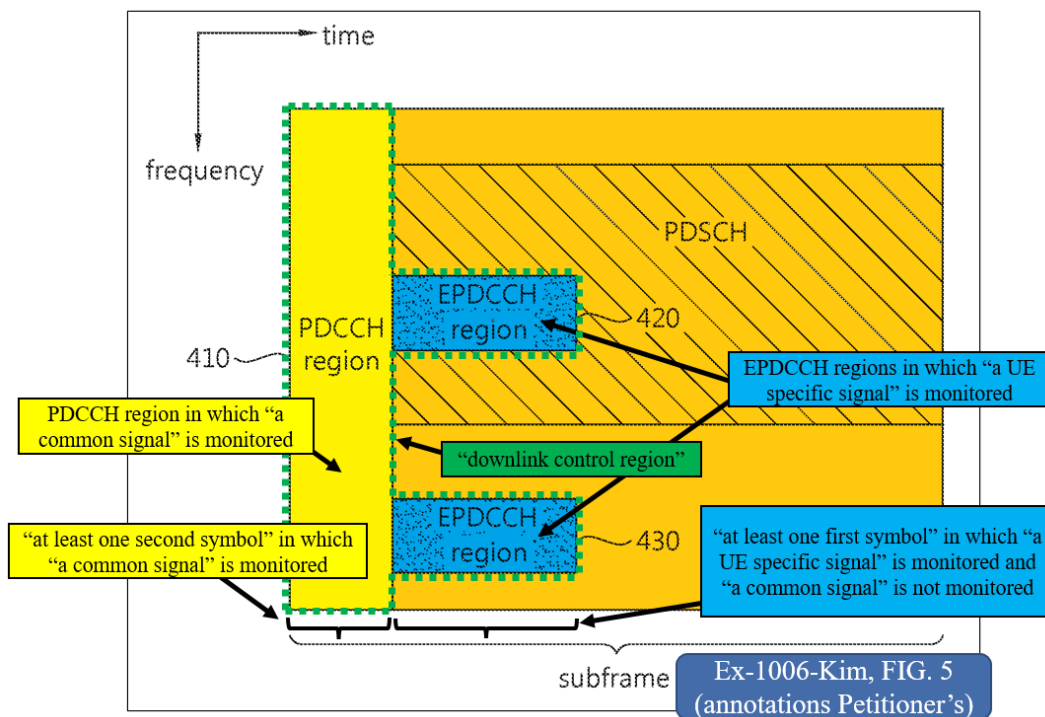


Figure 28 Kim's FIG. 5 demonstrates that the downlink control region (outlined by the Petitioner in green) encompasses both the PDCCH (highlighted in yellow) and EPDCCH regions (highlighted in blue). The PDCCH contains the common search space (CSS) where a common signal is monitored. The EPDCCH contains the UE specific search space (USS) where a UE specific search space is monitored.

212. In FIG. 5, a subframe (bottom) is shown with a data region and a downlink control region (outlined by the Petitioner in green). The

downlink control region encompasses both the PDCCH (410, highlighted by the Petitioner in yellow) and the EPDCCH region (420 and 430, highlighted by the Petitioner in blue). The “PDCCH region 410 is located in up to the first four OFDM symbols of the subframe, whereas the EPDCCH regions 420 and 430 may be flexibly scheduled in an OFDM symbol located after the PDCCH region 410.” (Ex-1006-Kim at [0089].) The PDSCH “is allocated to the data region” (highlighted by the Petitioner in orange). (Ex-1006-Kim at [0035].)

213. The “downlink control region of a subframe” is identified with green dashes and comprises both the yellow PDCCH region and the blue EPDCCH regions. (*See* §VI.) As embodiments discussed below will show, UE-specific signals are monitored in the EPDCCH regions in the “first” symbols corresponding to those EPDCCH regions, while the “common signal” is not monitored in those symbols and is monitored instead in the “second” symbols corresponding to the PDCCH region.
- a. **Kim teaches “monitoring, in the cell” UE-specific signals in a USS (UE-Specific search space) and common signals in a CSS (common search space)**
214. Kim teaches both UE-specific search spaces (called “USS”) and common search spaces (called “CSS”). (Ex-1006-Kim at [0105].)

215. Kim explains that blind decoding is used in 3GPP LTE to detect control information (UE specific signals or common signals) associated with PDCCH:

“The 3GPP LTE/LTE-A uses blind decoding for PDCCH detection. The blind decoding is a scheme in which a desired identifier is de-masked from a cyclic redundancy check (CRC) of a received PDCCH...If the PDCCH is for a specific wireless device, a unique identifier (e.g., cell-RNTI (C-RNTI)) of the wireless device may be masked to the CRC...When the C-RNTI is used, the PDCCH carries control information for a specific wireless device (such information is called UE-specific control information [UE specific signal]), and when other RNTIs are used, the PDCCH carries common control information [common signal] received by all or a plurality of wireless devices in a cell.” (Ex-1006-Kim at [0046]-[0047].)

216. Kim explains that a UE monitors a PDCCH in a specific search space (or specific set of control channel elements (CCE) in order to reduce the amount of blind decoding that must be done:

“The 3GPP LTE uses a search space to reduce a load of blind decoding. The search space can also be called a monitoring set of a CCE for the PDDCH. The wireless device monitors the PDCCH in the search space.” (Ex-1006-Kim at [0058].)

217. A search space helps the UE to limit its monitoring of the PDCCH with UE specific signals or common signals:

“The search space is classified into a common search space and a UE-specific search space. The common search space is a space for searching for PDCCH having common control information [common signal]...” (Ex-1006-Kim at [0059].)

“Hereinafter, a USS and a CSS denote a USS and a CSS in a PDCCH region, and an enhanced-USS (E-USS) and an enhanced-CSS (E-CSS) denote a USS and a CSS in an EPDCCH region. The CSS is a region monitored by a plurality of wireless devices in a cell or all wireless devices in the cell.” (Ex-1006-Kim at [0126].)

218. One of ordinary skill in the art would have understood that a UE monitors USS and E-USS portions of a subframe for UE-specific signals, and CSS and E-CSS portions of a subframe for common signals.

219. Accordingly, Kim discloses a UE “monitoring, in the cell, a UE specific signal” [11.2] and “monitoring, in the cell, the common signal” [11.4].

b. Kim teaches subframe configurations in which UE-specific signals (in an “E-USS”) are monitored in symbols corresponding to the EPDCCH region of the downlink control region in which common signals (in an “E-CSS”) are not monitored

220. Kim discloses an enhancement where UEs monitor an “enhanced” PDCCH region (referred to as an “EPDCCH”, it is considered part of the downlink control region) via E-USS and/or E-CSS.

“Hereinafter, a USS and a CSS denote a USS and a CSS in a PDCCH region, and an enhanced-USS (E-USS) and an enhanced-CSS (E-CSS) denote a USS and a CSS in an EPDCCH region. The CSS is a region monitored by a plurality of wireless devices in a cell or all wireless devices in the cell.” (Ex-1006-Kim at [0126].)

221. One of ordinary skill in the art would understand that E-USS denoted an enhanced user specific search space and an E-CSS denotes an enhanced common search space. One of ordinary skill in the art would understand that a UE would monitor an enhanced-USS (E-USS) or an enhanced-CSS (E-CSS) in an EPDCCH region for a UE specific signal or common signal respectively.

222. Kim further explains that the EPDCCH regions are scheduled in symbols located after the symbols corresponding to the PDCCH region:

“The PDCCH region 410 is located in up to first four OFDM symbols of the subframe, whereas the EPDCCH regions 420 and 430 may be flexibly scheduled in an OFDM symbol located after the PDCCH region 410.” (Ex-1006-Kim at [0089].)

223. Figure 5 (reproduced above) shows this pictorially. In this image, the symbols corresponding to the PDCCH region do not overlap with the symbols corresponding to the EPDCCH region. The PDCCH in Kim discloses in “the at least one second symbol” of limitation 11.4 as it is located in “up to the first four OFDM symbols of the subframe” and the EPDCCH in Kim discloses “the at least one first symbol” of limitation 11.2 because they are located “in an OFDM symbol located after the PDCCH region 410.”

224. Table 5 of Kim describes various subframe configurations for a PDCCH and an EPDCCH.

“...a subframe configuration for a PDCCH and an EPDCCH will be described...in...the table ‘O’ indicates that a corresponding search space exists in a corresponding subframe.” (Ex-1006-Kim at [0131]-[0134].)

TABLE 5

Subframe configuration	CSS (PDCCH)	USS (PDCCH)	E-CSS	E-USS	Exemplary usage
1	○				CSS fallback
2		○			USS fallback
3			○		E-CSS only
4				○	E-USS only
5	○	○			PDCCH only
6	○		○		CSS/E-CSS
7	○		○	○	partitioning CSS/USS partitioning
8		○	○		
9		○	○		
10		○	○		EPDCCH only
11	○	○	○		
12	○	○	○	○	CSS fallback
13	○		○		
14		○	○		
15	○	○	○		
16					N/A

“a common signal” is not monitored in the same symbols of the EPDCCH regions

Figure 29 Table 5 from Kim demonstrating subframe configurations for the PDCCH region (highlighted in yellow by the Petitioner) and the EPDCCH region (highlighted in blue by the Petitioner). The Petitioner has annotated the figure to illustrate that UE specific signals and not common signals are monitored in the EPDCCH region.

225. In configurations 7 and 12 of table 5, the UE monitors for a “UE specific signal” in the “the at least one first symbol” in the E-USS (highlighted by Petitioner in a blue box) of the EPDCCH portion of the control region while not monitoring for a “common signal” in the “the at least one first symbol” in the E-CSS (outlined by Petitioner in a red box) of the EPDCCH. Thus, Kim discloses limitations 11.2-11.3.
226. Kim also teaches limitation 11.4 since Kim discloses subframe configurations (configurations 7 and 12) in which the UE monitors for a common signal in the “at least one second symbol” of an CSS

associated with the PDCCH downlink control region (highlighted by the Petitioner in yellow boxes in table 5).

227. Thus, Kim teaches limitations 11.2-11.4.

4. [11.5] wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.

228. Kim, and Kim in view of R1-112517, teach this limitation.

229. First, this limitation is taught, suggested, and obvious over Kim alone because Kim shows that the number of symbols allocated by corresponding downlink control signaling may vary. FIG. 4 and FIG. 5, below illustrate two different options:

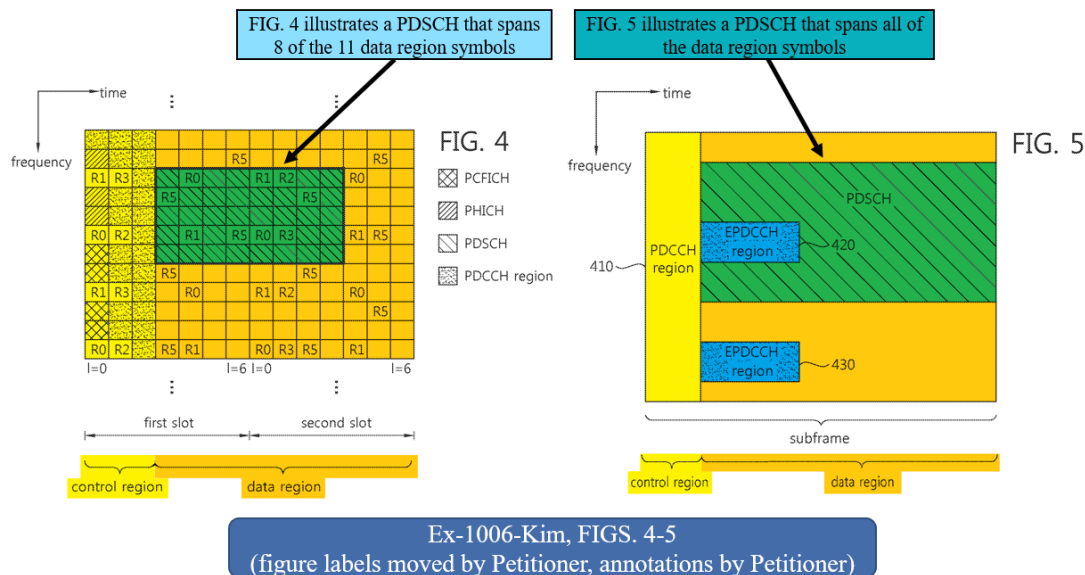


Figure 30 *FIG. 4 of Kim demonstrates a PDSCH region (highlighted in green) defined by signals in the PDCCH region that spans only 8 of the 11 symbols of the data regions. FIG. 5 of Kim demonstrates a PDSCH region (highlighted by the Petitioner in green) defined by signals in the EPDCCH DL control region that spans all 11 symbols of the data region.*

230. One of ordinary skill in the art would understand that the UE would monitor for the common signal in the CSS of the PDCCH downlink

control region to allocate the corresponding PDSCH symbols in the data region. One of ordinary skill in the art would also understand, from FIG. 4, that the common signal allocated resources in only 8 out of the 11 PDSCH symbols. One of ordinary skill in the art would understand that the UE would monitor for the UE specific signal in the E-USS of the EPDCCH downlink control region to allocate the corresponding PDSCH symbols in the data region.

231. One of ordinary skill in the art would also understand, from FIG. 5, that the UE specific signal allocated resources in 11 of the PDSCH symbols. One of ordinary skill in the art would understand that the fact that the common signal and the UE specific signals allocated resources of different lengths indicated that they allocated resources in different symbols of the data region. For instance, the common signal (from the PDCCH) could not allocate resources in symbol 10 in the data region (because it was only capable of allocating symbols 1-8 in the data region) while the UE specific signal (from EPDCCH) could allocate resources in symbol 10 in the data region, therefore when the UE specific signal allocates resources in symbol 10 in the data region the resources the common signal allocated in the data region would have to be different. As such, Kim discloses and renders obvious limitation 11.5 by indicating the data resources of differing durations may be indicated by the common signal and the UE specific signal.

232. Kim in view of R1-112517 also teaches this limitation.

233. R1-112517 details the ePDCCH design issues that were discussed in the 3GPP TSG-RAN1#66 meeting in order to extend the capacity of DL control channels. In particular, “To preserve backward

compatibility with legacy DL control channel, the use of resources in the legacy PDSCH region...is needed to design the enhanced DL control channel and associated design aspects will include resource allocation, multiplexing, RS utilization, etc.” (Ex-1010-R1-112517 at §1.) In that discussion, the idea of RB-based ePDCCH multiplexing was introduced where only the first slot is used for ePDCCH transmission: “In Fig. 1(b), only the PRB in the first slot is used for transmission of eCCEs while the PRB in the second slot is used for transmission of a PDSCH. The number of REs in an eCCE is similar to that of the legacy CCE. Such a design will also shorten the decoding time of an ePDCCH and PDSCH decoding can start from the second slot once a DL grant is detected.” (Ex-1010-R1-112517 at §2.) This instance is shown in the figure below:

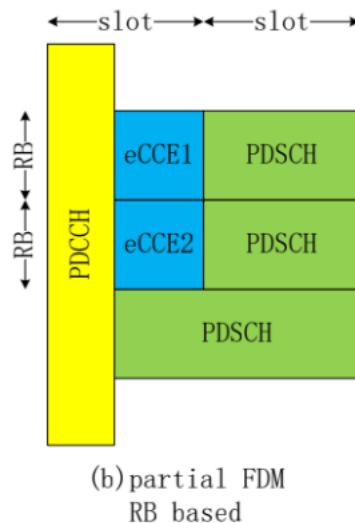


Figure 31 *RB-based ePDDCH from Samsung (Ex-1010-R1-112517, Fig.1(b).)*

234. As shown in this figure, the conventional downlink control region and the enhanced control region are both transmitted in the first slot of a subframe. One of ordinary skill in the art would understand from Fig.

1(b) of R1-112517 that the UE specific signals monitored as the UE decodes the eCCEs in the EPDCCH would allocate resources in the PDSCH immediately following them, whereas the PDCCH would allocate resources in the PDSCH that spanned the two slots, thus common signals (in PDCCH) and UE specific signals (in EPDCCH) would indicate resources in different symbols of the data region. R1-112517 teaches this limitation.

235. One of ordinary skill in the art would have been motivated and found it obvious to apply the teachings of R1-112517 to Kim. As shown above, Kim discloses using common signals in a PDCCH region and UE-specific signals in EPDCCH regions to indicate resources in a data region. R1-112517 teaches an efficiency enhancement wherein the enhanced signals indicate resources in the second slot of the subframe rather than in both slots. In adopting R1-112517, Kim's common and UE specific control signals would each indicate data resources in the data region (PDSCH) that are not coextensive, as they would be in different symbols. The resources indicated by the UE-specific signals would be in the symbols corresponding to the second slot of the subframe only, whereas the common signals may indicate resources throughout all of the data region symbols (e.g., symbols 4-14 in a typical subframe having a 3-symbol PDCCH region).
236. Thus Kim in view of R1-112517 teaches this limitation, and Kim in view of 3GPP-36.300 and R1-112517 renders obvious claim 11.

5. [Claim 12] The method of claim 11, wherein the common signal and the UE specific signal indicate resources in completely different or partially different symbols of the data region of the subframe.

237. As explained above, Kim in view of 3GPP-36.300 and R1-112517 discloses resources in (at least) partially different symbols. Thus Kim in view of 3GPP-36.300 and R1-112517 renders obvious claim 12 for the reasons discussed above.

6. [Claim 13] The method of claim 11, wherein the UE monitors the UE specific signal in the second symbol.

238. Kim discloses this limitation. Specifically, as discussed with respect to limitations 11.2-11.4, the PDCCH of Kim's FIGS. 4-5 is located in the "second" symbol. Subframe configuration 12 in Kim's Table 5 demonstrates the UE may monitor the UE specific signal (highlighted by the Petitioner in blue) in both EPDCCH and PDCCH.

TABLE 5					
Subframe configuration	CSS (PDCCH)	USS (PDCCH)	E-CSS	E-USS	Exemplary usage
2	○				CSS fallback
3	○				CSS fallback
4	○				CSS only
5	○				USS only
6	○	○			PDCCH only
7	○		○		CSS/E-CSS partitioning
8	○		○		CSS/USS partitioning
9	○		○		
10	○		○		EPDCCH only
11	○		○		
12	○	○	○	○	CSS fallback
13	○		○		
14	○		○		
15	○		○		
16					N/A

Figure 32 Subframe configuration 12 of Table 5 demonstrates that a UE-specific signal may be monitored in both a PDDCH downlink channel and a EPDCCH downlink control channel.

239. One of ordinary skill in the art would have understood that the UE specific signal associated with the PDCCH could occupy the second symbol of the subframe. Thus configuration 12 of Table 5 of Kim discloses monitoring a UE specific signal in the “second” symbol as required by this limitation.

240. Thus, Kim in view of 3GPP-36.300 and R1-112517 renders obvious claim 13.

7. [Claim 14] The method of claim 11, wherein the UE does not monitor the UE specific signal in the at least one second symbol.

241. Kim discloses this limitation. Specifically as discussed with respect to limitations 11.2-11.4, subframe configuration 7 in Kim’s Table 5 (see above) demonstrates the UE does not monitor the UE specific signal (highlighted by the Petitioner in blue) in the PDCCH.

242. Thus Kim in view of 3GPP-36.300 and R1-112517 renders obvious claim 14.

8. [Claim 15] The method of claim 11, wherein the UE specific signal is a signaling indicating resource allocation, a signaling indicating HARQ (Hybrid Automatic Repeat reQuest) feedback, and/or a reference signal for demodulation.

243. Kim in view of R1-112517 teaches this limitation. For the reasons discussed above relative to limitations 11.2-11.5, Kim in view of R1-112517 discloses monitoring a UE specific signal that indicates one or more resources allocated to the UE in a PDSCH data region.

244. Kim also discloses this limitation wherein the UE specific signal is a reference signal for demodulation.

“A UE specific reference signal (URS) is transmitted in the subframe. Whereas the CRS is transmitted in the entire region of the subframe, the URS is transmitted in the data region of the subframe and is used to demodulate the PDSCH. In FIG. 4, ‘R5’ indicates an RE used to transmit the URS. The URS is also called a dedicated reference signal (DRS) or a demodulation reference signal (DM-RS).” (Ex-1006-Kim at [0080].)

245. Kim indicates monitoring an EPDCCH for UE specific signals corresponding to DM-RS:

“In the EPDCCH regions 420 and 430, instead of the CRS, a DM-RS may be defined for demodulation of the EPDCCH. An associated DM-RS may be transmitted in the EPDCCH regions 420 and 430.” (Ex-1006-Kim at [0092].)

246. One of ordinary skill in the art would understand that the reference signal for demodulation (“DM-RS”) is a UE-specific signal associated with the EPDCCH.

247. Thus, Kim in view of R1-112517 discloses this limitation, and Kim in view of 36.300 and R1-112517 renders obvious claim 15.

9. [Claim 16] The method of claim 11, wherein the common signal is signaling indicating a system frame number (SFN), a signaling indicating resource allocation for a broadcast message, a synchronization signal, or a reference signal for DL radio condition measurement.

248. Kim in view of R1-112517 teaches this limitation. For the reasons discussed above relative to limitations 11.2-11.5, Kim in view of R1-112517 discloses monitoring a common signal in the PDCCH that indicates resource allocation in a corresponding PDSCH.

249. Kim also discloses monitoring the PDCCH for common signals corresponding to a synchronization signal:

“...a subframe in which a specific signal (e.g., PBCH, synchronization signal) is transmitted may be designated as the PDCCH subframe.” (Ex-1006-Kim at [0104].)

250. Kim also discloses monitoring the PDCCH for common signals indicating resource allocation for a broadcast message:

“The PDCCH subframe and the EPDCCH subframe may be properly combined and operated according to a feature of control information. For example, information for changing and updating importance information such as system information and cell selection/reselection information or broadcast information or information masked with SI-RNTI, P-RNTI, and RA-RNTI may be monitored in a PDCCH region, and scheduling information (i.e. DL grant and UL grant may be monitored in the EPDCCH.” (Ex-1006-Kim at [0105].)

251. Thus, Kim in view of R1-112517 discloses this limitation, and Kim in view of 3GPP-36.300 and R1-112517 renders obvious claim 15.

10. [Claim 17] The method of claim 11, wherein a length of the downlink control region is two symbols and the UE does not monitor the UE specific signal in the at least one second symbol.

252. Kim teaches and renders obvious a control region that is exactly two symbols long in duration. In the context of FIG. 5, Kim discloses:

“FIG. 5 is an example of a subframe having an EPDCCH. The subframe may include zero or one PDCCH region 410 and zero or more EPDCCH regions 420 and 430.

The EPDCCH regions 420 and 430 are regions in which a wireless device monitors the EPDCCH. The PDCCH region 410 is located in up to first four OFDM symbols of the subframe, whereas the EPDCCH regions 420 and 430 may be flexibly scheduled in an OFDM symbol located after the PDCCH region 410.” (Ex-1006-Kim at [0087]-[0091].)

253. One of ordinary skill in the art would understand that the downlink control region was comprised of both the EPDCCH regions 420 and 430 and the PDCCH region 410 (as shown by the green outline added by the Petitioner in FIG. 5). One of ordinary skill in the art would also understand from the above excerpt that the PDCCH is located in “up to the first four OFDM symbols”, and could be relegated to just one OFDM symbol. One of ordinary skill in the art would understand that given (from the excerpt above) the EPDCCH could be scheduled in an (i.e., a single) OFDM symbol located after the PDCCH region, the PDCCH could occupy one symbol and the EPDCCH could occupy a second symbol to render a downlink control region with a length of two symbols. Kim discloses “wherein a length of the downlink control region is two symbols”.
254. Accordingly, in the context of subframe configuration 7 in Kim (discussed above regarding claim 11), the downlink control region would be two symbols, with UE-specific signals being monitored in the “first” EPDCCH symbol, common signals being monitored in the “second” PDCCH symbol that precedes the EPDCCH region, and with no UE-specific signals being monitored in the PDCCH region of the “second” symbol.

255. Thus Kim teaches this limitation and Kim in view of 3GPP-36.300 and R1-112517 renders obvious claim 17.

11.[18.0] A User Equipment (UE) for communication with a network node, comprising:

256. Kim teaches this preamble for the reasons provided above regarding 11.0

12.[18.01] a control circuit:

[18.02] a processor installed in the control circuit; and

[18.03] a memory installed in the control circuit and operatively coupled to the processor;

[18.04] wherein the processor is configured to execute a program code stored in the memory to:

257. Kim teaches these limitations. For example, Kim discloses implementing its teachings in a UE:

“A wireless device 60 includes a processor 61, a memory 62, and an RF unit 63. The memory 62 is coupled to the processor 61, and stores a variety of information for driving the processor 61. The RF unit 63 is coupled to the processor 61, and transmits and/or receives a radio signal. The processor 61 implements the proposed functions, procedures, and/or methods. Layers of a radio interface protocol can be implemented by the processor 61. The processor 61 can monitor an EPDCCH and a PDCCH in a search space. The processor may include Application-Specific Integrated Circuits (ASICs), other chipsets, logic circuits, and/or data processors. The memory may include Read-Only Memory (ROM), Random Access Memory (RAM), flash memory, memory cards, storage media and/or other storage devices. The RF unit may include a baseband circuit for processing a radio signal. When the above-described embodiment is implemented in software, the above-described scheme may be implemented using a module (process or function) which performs the above function. The module may be stored in the memory and executed by the processor. The memory may be disposed to the processor internally or externally and connected to the processor using a variety of well-known means.” (Ex-1006-Kim at 15:30-52; *see id.* at FIG. 8.)

258. One of ordinary skill in the art would have understood that a module stored in the memory would be program code. One of ordinary skill in

the art would also understand that a processor, in order to operate and execute programs from the memory, is installed in a control circuit which connects it to the memory. Thus, Kim discloses a processor and memory, operatively coupled together and installed in control circuitry to execute a program code in the memory to implement limitations 18.1-18.5 and claims 19-24.

259. Thus, Kim teaches these limitations.

13.[18.1] communicate with the network node in a cell via downlink and uplink transmissions, wherein the downlink and uplink transmissions are organized into radio frames, each radio frame includes multiple subframes, and each subframe includes multiple symbols;

260. Kim in view of 3GPP-36.300 teaches this limitation for the reasons provided above regarding limitation 11.1.

14.[18.2] monitor, in the cell, a UE specific signal in at least one first symbol of a downlink control region of a subframe,

[18.3] and not monitoring a common signal in the at least one first symbol; and

[18.4] monitor, in the cell, the common signal in at least one second symbol of the downlink control region,

261. Kim teaches these limitations for the reasons provided above regarding limitations 11.2-11.4.

15.[18.5] wherein the common signal and the UE specific signal indicate resources in different symbols of a data region of the subframe.

262. Kim in view of Samsung teaches the limitation, Kim in view of 3GPP-36.300 and Samsung renders obvious claim 18.

16. Claims 19-24

263. Claims 19-24 include the same limitations as claims 12-13, 15-17, and 14 respectively, and thus are obvious for the same reasons provided above relative to those claims.

X. CONCLUSION

264. I hereby declare that all statements made herein are of my own knowledge and are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on this 5th day of August 2024, at Cambridge, Massachusetts.



Michael Allan Martin Davies

Michael A M Davies

Curriculum Vitae

Michael A M Davies

Chairman and Senior Partner, Endeavour.Partners
Senior Lecturer, Massachusetts Institute of Technology
Guest Lecturer, London Business School
Co-founder and CEO, WKD.SMRT, Inc.
Co-founder and former Chairman, Silverthread Inc.

Expertise

Michael Davies' specialist expertise and relevant experience cover the technical, business, strategic, economic, and broad policy issues involved in deep high tech and throughout the high-tech sector—in particular mobile devices and services—and wireless (cellular and satellite) and broadband networks, consumer electronics, the Internet of Things (IoT), electronic components, and semiconductors.

- the architecture and economics of communication services networks and computing services, in particular broadband cellular, fiber infrastructure, packet networks, cloud services, computing services, 'edge computing' services, satellite networks, video codecs, robotics, payment systems, IoT, and smart home technologies
- the architecture and economics of state-of-the art electro-mechanical devices, systems, and components that combine hardware and software, in particular mobile devices and systems, consumer electronics, personal computing and cloud computing, hardware manufacturing, semiconductors, and the related supply chains
- creative business models, co-opetition, and building business ecosystems, including open innovation, open source, shared infrastructure, and other ground-breaking approaches
- the economics of systems, platforms, architecture, modularity, and bottlenecks, in particular as this relates to complex products and services that combine software, computing, and communications
- consumer behavior and segmentation and the adoption and diffusion for high-tech that are novel products
- strategy and management for R&D, product creation, and technological innovation; knowledge-intensive technical teams, such as R&D staff; effective work practices; and the economics of innovation and intellectual property (trade secrets, patents, and licensing strategies)
- harnessing digital technologies knowledge and the challenges associated with innovation and how to address them

Michael has several areas of specialist expertise relevant to these challenges:

- consumers' purchase preferences and buying behaviors as well as projects adoption and diffusion of new technologies;
- anticipates the future by developing insight into the co-evolution of technological innovation and technology architecture, the potential demand opportunity, and platforms and business ecosystems;
- develops creative and robust business strategies by identifying opportunities and options for initiatives, investments, and novel business models that create and capture value; and
- provides effective leadership through decision-making under uncertainty, agile methods, and building resilience

Michael A M Davies

Curriculum Vitae

Experience

Michael has worked for more than forty years in high tech telecommunications and mobile devices.

His experience spans the design, development, and deployment of mechanical, electrical, electronic, and high-tech products; manufacturing; software coding; video; supply chain management; research and development; technology; product creation; and business strategy.

Endeavour.Partners provides services to:

- delivers expert witness testimony on matters related to public policy, intellectual property, and commercial relationships within the mobile, wireless, and digital sectors
- provides consulting services on business strategy to companies throughout the mobile and wireless industry, including cellular infrastructure providers, mobile device manufacturers, and mobile network operators; companies involved in the broadband, fiber and satellite sectors
- provides consulting services on business strategy to industrial companies that are being impacted by digital and other deep technology

As a Senior Lecturer at MIT, Michael:

- created and taught courses in fundamental and advanced topics in technology strategy, systems engineering, leadership of high-tech businesses, and integrated design and product development process in both the School of Engineering (in Aero/Astro) and in the Sloan School of Management
- teaches creative innovation, value creation, emerging technologies, product management, product marketing, basic finance and business models, pricing and marketing, competitive analysis, market opportunity identification, funding entrepreneurship, data-driven decision-making, and decision-making under uncertainty
- created and leads, with colleague Blade Kotelly, Breakthrough Innovation: Creating Value in Times of Uncertainty

As a Guest Lecturer at the London Business School, Michael:

- created and for more than a decade has taught the New Technology Ventures program, which enables emerging entrepreneurs to evaluate novel ideas and inventions and turn them into new technology ventures
- created and serves as course Academic Director for the path-breaking course on The Business of AI.

As the Founder of WKD.SMRT, Michael:

- leads a company that is accelerating innovation in healthcare by provide superior real-life data for clinical trials, through a turnkey solution that combines state-of-the-art technologies in sensing, machine learning, and computer processing

As the Founder of Silverthread Inc, Michael:

- founded a company that helps clients diagnose and improve the economics of maintaining, evolving, and developing very large-scale software systems

Michael A M Davies

Curriculum Vitae

Education

London Business School

1989–1991

Master of Business Administration (With Distinction)

- Specialized in Business Strategy, Technology Management, and Decision Sciences
- Participated in the PhD Program on Systems Dynamics

University of Durham, UK

1982–1984

Master of Engineering

- Microelectronics
- Cybernetics and Robotics
- Management Science

St Catharine's College, University of Cambridge

1979–1987

Bachelor of Arts (1982) and Master of Arts (1987)

- Electrical Sciences Tripos (Computer Science, Mathematics, Engineering, and Physics)
- Engineering Part I and Part II

Harvard Business School

Post-graduate study in Innovation & Organizations

Michael A M Davies

Curriculum Vitae

Expert Reports and Testimony Experience

United States of America et al v AT&T Inc et al.

- Department of Justice anti-trust investigation, Civil Action No. 11-01560 (ESH)
- Industry Expert: Antitrust
- Expert Report (2011)

Apple Inc v Samsung Electronics America Inc, Samsung Telecommunications America LLC, and Samsung Electronics Co Ltd

- International Trade Commission Investigation No. 337-TA-796
- Industry Expert: Public Interest
- Expert Declaration (2013)

Ericsson Inc and Telefonaktiebolaget LM Ericsson v Samsung Electronics America Inc, Samsung Telecommunications America LLC, and Samsung Electronics Co Ltd

- International Trade Commission Investigation No. 337-TA-862
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony, Hearing Testimony (2013)

Samsung Electronics Co Ltd and Samsung Telecommunications America LLC v Ericsson Inc and Telefonaktiebolaget LM Ericsson

- International Trade Commission Investigation No. 337-TA-866
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony, Hearing Testimony (2013)

InterDigital Communications Inc, InterDigital Technology Corporation IPR Licensing Inc, and InterDigital Holdings v Samsung Electronics America Inc and Samsung Telecom America LLC

- International Trade Commission Investigation No. 337-TA-868
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony, Hearing Testimony (2013)

Sasken Communication Technologies Limited v Spreadtrum Communications Inc and Spreadtrum Communications USA

- American Arbitration Association, International Centre for Dispute Resolution No. 50-117-T-0092-12
- Technical Expert and Industry Expert: Arbitration
- Expert Report, Deposition Testimony, Hearing Testimony (2013)



Endeavour.Partners

4

June 2024

Michael A M Davies

Curriculum Vitae

On Track Innovations LTD v T-Mobile USA Inc

- United States District Court, Southern District of New York No. 12-cv.02224-AJN-JCF
- Technical Expert
- Expert Report, Deposition Testimony (2013-2014)

Hand Held Products Inc v Amazon.com Inc et al.

- United States District Court, District of Delaware No. 1:12-CV-00768-RGA-MPT
- Technical Expert
- Expert Report, Code Analysis (2014)

Enterprise Systems Technologies SARL v Samsung Electronics America Inc, Samsung Electronics Co Ltd, and Samsung Telecommunications America LLC

- International Trade Commission Investigation No. 337-TA-925
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony (2015)

NVIDIA Corporation v Samsung Electronics America Inc, Samsung Electronics Co Ltd, and Samsung Telecommunications America LLC

- International Trade Commission Investigation No. 337-TA-932
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony, Hearing Testimony (2015)

Nokia Corporation v Samsung Electronics Co Ltd

- Arbitration, International Chamber of Commerce No. 19602/AGF/RD (c.19638/AGF)
- Industry Expert and Technology Expert: intellectual property, patent royalties
- Expert Report, Deposition Testimony, Hearing Testimony (2015)

Ericsson Inc and Telefonaktiebolaget LM Ericsson v Apple Inc

- International Trade Commission Investigation No. 337-TA-952
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony, Hearing Testimony (2015)

Core Wireless Licensing SARL v LG Electronics Inc and LG Electronics Mobilecomm USA Inc

- United States District Court, Eastern District of Texas No. 2-14-cv-00911-JRG-RSP
- Technical Expert
- Expert Declaration, Expert Report, Deposition Testimony (2015)

Michael A M Davies

Curriculum Vitae

St. Lawrence Communications v ZTE Corporation

- United States District Court, Eastern District of Texas No. 2:15-cv-394-JRG and 2:15-cv-00351-JRG
- Technical Expert
- Preliminary work performed; case settled (2016)

ParkerVision Inc v Apple Inc, Samsung Electronics Co Ltd, Samsung Electronics Inc, LG Electronics Inc, LG Electronics Mobilecomm USA Inc, and Qualcomm Inc

- International Trade Commission Investigation No. 337-TA-982
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony (2016)

T-Mobile USA Inc v Huawei Device USA Inc and Huawei Technologies Co Ltd

- United States District Court, Western District of Washington No. 14-cv-01351-RAJ
- Industry Expert: Trade Secrets
- Expert Report, Deposition Testimony (2016), Declarations, Trial Testimony (2017)

Immersion Corporation v Apple Inc and AT&T Mobility LLC

- International Trade Commission Investigation No. 337-TA-1004/990
- Industry Expert: Public Interest
- Expert Report (2016), Deposition Testimony, Hearing Testimony (2017)

Netlist Inc v SK hynix America Inc, SK hynix Inc, SK hynix memory solutions Inc

- International Trade Commission Investigation No. 337-TA-1023
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony, Hearing Testimony (2017)

Andrea Electronics Corporation v Samsung Electronics America Inc and Samsung Electronics Co Ltd

- International Trade Commission Investigation No. 337-TA-1026
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony (2017)

Motorola Solutions Inc v Hytera America Inc and Hytera Communications America (West) Inc

- International Trade Commission Investigation No. 337-TA-1053
- Technical Expert
- Inter Partes Review, Expert Report, Rebuttal Report, Deposition Testimony (2017)

Michael A M Davies

Curriculum Vitae

WILAN v LG Electronics Inc

- United States District Court, Southern District of California No. 3:17-cv-00358-BEN-BGS
- Technical Expert
- Preliminary work performed; case settled (2017)

Huawei Technologies Co Ltd et al. v Samsung Electronics Co Ltd et al.

- United States District Court, Northern District of California No. 16-cv-02787-WHO
- Technical Expert: Standards Essential Patents
- Expert Report (2018)

Seven Networks Inc v Google LLC

- United States District Court, Eastern District of Texas No. 2:17-CV-00442-JRG
- Technical Expert
- Expert Report (2018)

BITMICRO LLC v Samsung Electronics America Inc, Samsung Electronics Co Ltd, SK Hynix America Inc, and SK Hynix Inc

- International Trade Commission Investigation No. 337-TA-1097
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony (2018)

United States of America et al. in the matter of T-Mobile USA Inc and Sprint Corporation

- United States District Court, District of Columbia No. 1:19-cv-02232-TJK
- Technical Expert and Industry Expert: industry background, anti-trust, economics
- Expert Report, Model (2018)

EVS Codec Technologies and St Lawrence Communications v Sony Mobile Communications Inc

- United States District Court, Southern District of New York No. 1:18-cv-09518-JSR
- Technical Expert and Industry Expert: intellectual property, patent royalties
- Expert Declarations, Expert Report (2019)

Michael A M Davies

Curriculum Vitae

Peloton Interactive Inc v Flywheel Sports Inc

- United States District Court, Eastern District of Texas 2:2018-cv-00390-RWS-RSP and 2:19-cv-00317-JRG-RSP
- Industry Expert: Trade Secrets, Intellectual Property, Inter Partes Review, Indicia of Non-obviousness
- Expert Reports (2020)

Neodron Limited v Samsung Electronics Co Ltd, Amazon.com Inc, Motorola Mobility LLC, Microsoft Corp, and Apple Inc

- International Trade Commission Investigation No. 337-TA-1162 and No. 337-TA-1193
- Industry Expert: Public Interest
- Expert Report (2020)

Helios Towers plc v Orange SA

- Arbitration, International Chamber of Commerce No. 25115/dda
- Technical Industry Expert: Arbitration
- Expert Report (2020)

United States of America v Huawei Technologies Co Ltd

- Western District of Washington Docket No. CR19-010-RSM
- Eastern District of New York Docket No. 18-CR-457 (AMD)
- Industry Expert: Theft of trade secrets, and conspiracy to steal trade secrets, violating the Racketeer Influenced and Corrupt Organizations (RICO) Act
- Advisory capacity (2020)

RED v CloudMinds Inc

- JAMS Arbitration No. 1220062943
- Technical Expert and Industry Expert: Arbitration
- Expert Report, Deposition Testimony, Hearing Testimony (2020)

Nokia Corporation v Lenovo Group Limited

- International Trade Commission Investigation No. 337-TA-1208
- Industry Expert: Public Interest, Domestic Industry, Bonding
- Expert Report, Deposition Testimony (2020)

Michael A M Davies

Curriculum Vitae

Evolved Wireless LLC v Samsung Electronics Co Ltd and others

- International Trade Commission Investigation No. 337-TA-1253
- Industry Expert: Public Interest
- Expert Report, Deposition Testimony (2021)

Competition Bureau of Canada in the matter of Rogers Communication and Shaw Communication

- Assessment of the proposed acquisition by Rogers Communication of Shaw Communication
- Industry Expert: Public Interest
- Expert Report for §104 Injunction
- Expert Report for §92 Hearing
- Testimony at Competition Tribunal
- Affidavit for Stay and Injunction for Appeals Court Canada (2021)

Sonrai Memory Limited v Intel Corp (on behalf of Dell Technologies Inc, Lenovo Group Limited, and LG Electronics Inc), Samsung Electronics Co Ltd, and Samsung Electronics America

- International Trade Commission Investigation No. 337-TA-1280
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony (2021)

Ericsson Inc v Apple Inc

- International Trade Commission Investigation No. 337-TA-1299
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony, Hearing Testimony (2022)

Ericsson Inc v Apple Inc

- International Trade Commission Investigation No. 337-TA-1300
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony, Hearing Testimony (2022)

Ericsson Inc v Apple Inc

- International Trade Commission Investigation No. 337-TA-1301
- Industry Expert: Public Interest
- Expert Report, Rebuttal Expert Report, Deposition Testimony, Hearing Testimony (2022)

Michael A M Davies

Curriculum Vitae

AliveCor Inc v Apple Inc

- International Trade Commission Investigation No. 337-TA-1266
- Industry Expert: Public Interest
- Declaration on Public Interest (2022)

Arigna Technology Limited v Apple Inc

- International Trade Commission Investigation No. 337-TA-1308
- Industry Expert: Public Interest
- Expert Report, Rebuttal Report, Deposition Testimony (2022), Hearing Testimony (2023)

United States of America v Google LLC

- United States District Court, District of Columbia No. 1:20-cv-03010-APM
- Technical Expert and Industry Expert: Industry background, anti-trust
- Expert Report, Reply Report, Deposition Testimony (2020)

Department of Justice, Anti-Trust Division, Media, Entertainment and Communications Section

- Anti-trust investigation in the communications services sector
- Industry Expert and Technical Expert: Anti-trust
- Advisory capacity (2022)

Daedalus Prime LLC v Samsung Electronics Co Ltd, Samsung Telecommunications America LLC, and Qualcomm Incorporated

- International Trade Commission Investigation No. 337-TA-1335
- Industry Expert: Public Interest
- Expert Report (2022)

Daedalus Prime LLC v Samsung Electronics Co Ltd, Samsung Electronics America Inc, Taiwan Semiconductor Manufacturing Company Limited, and TSMC North America

- International Trade Commission Investigation No. 337-TA-1336
- Industry Expert: Public Interest
- Expert Report. (2022)

Michael A M Davies

Curriculum Vitae

Masimo Corporation v Apple Inc

- International Trade Commission Investigation No. 337-TA-1276
- Industry Expert: Public Interest
- Declaration on Public Interest (2023)

PayRange Inc v KioSoft Technologies LLC

- United States District Court, Southern District of Florida No. 1:20-CV-24342-RNS
- Technical Expert and Industry Expert: intellectual property, damages estimation
- Expert Report, Rebuttal Report, Deposition (2023)

Interdigital Inc v Samsung Electronics Co Ltd

- Arbitration, International Chamber of Commerce No. 27699/PDP
- Industry Expert: Arbitration
- Expert Report (2023), Rebuttal Report (2024)

ASUS Inc v Samsung Electronics Co Ltd

- Technical legal case No. 2:23-CV-00409-JRG-RSP
- Technical Expert
- Inter Partes Review

Telefonaktiebolaget LM Ericsson v Lenovo (United States)

- International Trade Commission Investigation No. 337-TA-1387
- Industry Expert: Public Interest
- Expert Report

Professional Experience

Endeavour.Partners

Founder and Chairman

2003–Present

Endeavour.Partners is a boutique consulting firm that empowers business leaders to create a future that is more prosperous and more humane, equitable, sustainable, and resilient by harnessing digital technologies—and other deep technologies—to create new value and accelerate growth both in leading technology and for other global leaders worldwide in many diverse sectors to harness digital and deep technology.

Endeavour.Partners leverages its deep and broad expertise in technology to help achieve positive outcomes for people and the planet in vital and critical areas, such as anti-trust and the public interest, which encompasses, for example, public health and welfare, competitive conditions, and outcomes for consumers.



Michael A M Davies

Curriculum Vitae

Michael and his team have experience working throughout the digital ecosystem: across mobile, cellular, satellite, Internet, and digital convergence and commerce. This includes extensive work in communications, in particular mobile devices (feature phones, smartphones, tablets, cameras, connected homes, smart homes), services (video/PnP, data, messaging, mobile payment, codecs, Bluetooth), components (processor, memory, sensors), cellular and satellite networks (network infrastructure and equipment), broadband and Internet, computing (from semiconductors through personal computing to software services), consumer electronics, content (video, audio, gaming), commerce, and convergence of these domains.

The firm specializes in technological innovation, the adoption and diffusion of new products, and the emergence and evolution of business ecosystems from a systems point of view. This expertise encompasses the key digital technologies redefining business, the economy, and society: smartphones, cloud services, the Internet of things (IoT), Artificial Intelligence (AI), and robotics.

The firm is headquartered in Cambridge, MA, with a presence in Seattle, WA, and in London, United Kingdom.

Clients

Endeavour.Partners clients include:

- most of the leading mobile device and connected consumer electronics vendors, including HTC, Samsung, Apple, Nokia, LG, Sony Ericsson, and Motorola
- leading network operators and service providers, such as Verizon Wireless, AT&T, Sprint, T-Mobile, Deutsche Telekom, Vodafone, BT, Optus, and Virgin Mobile
- network infrastructure owners and providers, such as Crown Castle, Samsung, and Lucent
- other firms throughout the high-technology supply chain, including semiconductor companies such as Intel, SK Hynix, Qualcomm, and Analog Devices
- leading global businesses in diverse sectors harnessing digital and other deep technologies, including Thomson Reuters, Swiss Re, Husqvarna, Arla, TetraPak, TechnipFMC, and A.C. Milan
- innovative new technology ventures, such as PowerByProxi, Soul Machines, and zero360
- leading public sector organizations, including public broadcaster WGBH and the American Archive of Public Broadcasting (AAPB)

Scope of Work

Michael's work through Endeavour.Partners exemplifies his wide-ranging expertise in business strategy, technology strategy, technology innovation, product creation, supply chain, and public policy issues. He has provided industry expertise in patent and antitrust litigations on behalf of:

- U.S. Department of Justice—anti-trust case over the proposed AT&T and T-Mobile merger (2011)
- Commercial Arbitration participants—industry and technical expert providing multi-billion-dollar patent arbitrations concerning both Standard Essential Patents (SEPs) and non-SEPs on mobile connectivity and mobile services
- ITC complainants and respondents—industry expert opining on the public interest for litigation focused on wireless infrastructure and networks, mobile devices, wearables, smart home devices, semiconductors, software applications, and digital ecosystems
- United States District Court plaintiffs and defendants—technical expert opining on the (in)validity and (non)infringement related to several technologies involved in mobile devices and wireless networks, including the capture and decoding of real-time video signals, communication on smartphones, and audio codecs

Michael A M Davies

Curriculum Vitae

Endeavour.Partners has also worked in strategy projects on behalf of:

- wireless carriers—video/PnP, 4G and LTE technologies, Bluetooth and data/messaging, particularly around innovative business models
- one of the world's largest and most successful network operators and service providers—video and media platform strategy
- a major wireless carrier—strategies in NFC technology and mobile payments, including a deep technical analysis of competing solutions, as well as assessment on the surrounding business ecosystem, viable business models, and drivers of consumer adoption patterns
- R&D department (~20,000 people) of one of the world's largest software development organizations—renewal of product creation
- world's number one mobile device vendor—"R&D University" for top management team (in collaboration with the world's top academics)
- world's number one consumer electronics business—the future of the consumer electronics, connected home devices, computing business ecosystem, and communications business ecosystem
- a multi-billion-dollar diversified global technology business—renewal of their technology management, from semiconductors through software platforms to devices and complete solutions
- top-tier service providers and network operators, such as BT and Deutsche Telekom—corporate and business strategy for communications services, software businesses, innovative start-ups, and infrastructure vendors
- world's number one device vendor—platform strategy for its flagship product line
- innovation leader in mobile devices—a family of modular products
- world's number one global provider of subsea robotics—new networking approaches for robust, high-bandwidth, multi-model subsea communications systems

Endeavour.Partners has also provided broad industry expertise in regard to:

- business strategies on Internet and mobile advertising, including market sizing, opportunity assessment, and business model deployment for various service providers
- business strategies on machine learning as a service, disease management, green hydrogen, carbon nanotubes, and sensors
- comprehensive projection of the medium- and long-term demand for all digital services and devices, and the related attributes driving consumer choice and preference, including projected market share for major players under a variety of alternative scenarios and the implications thereof
- analysis of the full spectrum of the communications sector, from underlying physical infrastructure, through cellular networks, fiber networks, and satellite networks
- standards for smart home products and connectivity

Michael A M Davies

Curriculum Vitae

WKD.SMRT, Inc.

Co-founder and Chief Executive Officer

2019–present

WKD.SMRT delivers superior real-life data for clinical trials in the home. Its solution makes clinical trials faster, easier, lower cost, and lower risk by combining state-of-the-art sensing, machine learning, and computing technologies to deliver data that is more precise, more complete, more objective, and more real-life.

It is partnering with the world's leading pharma company focused on neurodegenerative diseases, the world's number one academic neurology department, and the world's leading research group focused on the medical aspects of activities of daily living and quality of life.

Silverthread, Inc.

Co-founder, former Chairman

2013–present

Silverthread's services and tools help clients diagnose and improve the design architecture of large software systems to improve predictability of project schedules, reduce unnecessary overhead costs, and prevent compounding complexity. The company's clients include large corporations and government entities that own and manage large, complex software systems.

Zero-360

Co-Founder and founding Chairman

2012–2015

Strategic thought leader for this next-generation wearable device and solutions company focused on unique interactions and bio-sensing capabilities. Its particular focus is on how to support behavioral change. Zero-360's cloud platform provided an open and scalable solution that integrated with third-party wellness programs in capturing valuable health and wearable data.

EquuSys

Co-Founder and Chief Technology Officer

2004–present

EquuSys is an animal instrumental business that provides real-time, real-world data to enhance the evaluation, diagnosis, rehabilitation, training, and conditioning of elite horses. The company commercialized Michael's patented inventions, including the development of a hardware electronics sensor product and the accompanying software. This included developing novel wireless protocols for high-speed asymmetric data transmission in shared spectrum.

Mercator Partners

Founder and Chairman Emeritus

1998–2009

This technology strategy consulting firm designed, directed, and delivered training programs in strategy and technology. Its alumni now fill top strategy roles within a number of industry-leading firms, including Google, HTC, Nielsen, Yahoo!, Sony Ericsson, HTC, and Vodafone. Client work focused on building creative new business models and developing effective business strategies on behalf of:

- leading US mobile company—business ecosystems, business strategies, and anticipating likely customers behavior



Endeavour.Partners

14

June 2024

Michael A M Davies

Curriculum Vitae

- major global JV with European and Japanese parents—emerging applications and potential business models
- most successful MVNO in the world—data services, market entry, and partnership development
- several high-tech R&D-intensive businesses across consumer electronics, telecommunications, automotive, and aerospace—how to commercialize highly innovative technologies
- for the number one US communications infrastructure company—customer needs and company strategy for 3G mobile
- leading Japanese consumer electronics and industrial conglomerate—evolution of consumer electronics; monetizing its semiconductor intellectual property; consumer segmentation; creative business models; and product portfolios, pipeline, and positioning
- variety of media companies—business models and content plays in the Internet and mobile service space
- leading European mobile operator—values- and lifestyle-based consumer segmentations to increase customer loyalty and reduce costs
- several broadband and IP players—business models and market entry strategies
- several top-tier private equity players, such as The Carlyle Group, Providence Equity, Kohlberg Kravis Roberts, Blackstone, and Berkshire Partners—due diligence and strategic counsel on technology and telecom investments
- UK 3G auctions—assembled a consortium bid (SpectrumCo), and raising >\$4 billion for an innovative business model, with players such as Virgin, Sonera, Nextel, and Tesco, including strategies for sharing spectrum amongst multiple competing uses

GeoPartners Research

Principal

1996–1998

GeoPartners Research provided technology evaluation and strategy focused on broadband, IP, and next generation wireless technologies on behalf of and in regard to:

- AT&T—overall corporate strategy, including IP, VoIP, local entry, wireless and broadband, including network infrastructure and equipment (including NAT and DNS for VoIP)
- Qualcomm—new technologies, business ventures, and organizational design, including work on Qualcomm's first smartphone and on the design parameters for spectrum sharing on its next generation of data-oriented technologies such as EV-DO and EV-DV
- Ember Networks—the IEEE 802.15.4 and the standardization of the Zigbee protocols, and comparative evaluation of these protocols versus other wireless mesh protocols, with a particular focus on frequency hopping to mitigate interference in unlicensed spectrums
- HP, Northern Telecom (subsequently Nortel Networks), and Intel—business models and building business ecosystems

Michael A M Davies

Curriculum Vitae

AT&T (formerly BellSouth International)

Chief of Strategy, One NZ (formerly BellSouth NZ)

1992–1996

Corporate and business strategy, government relations and industry relations, and R&D, including:

- Chairman of the 3rd Generation Interest Group of the GSM MoU (the largest organization of mobile network operators in the world)—assessed the alternative protocols available for 3G, with particular focus on the use of frequency hopping and other techniques to mitigate interference, the requirements to support global roaming, and to qualify state-of-the-art mobile devices for advanced services
- Chairman of the New Zealand Personal Communications Services working group—assessed the coexistence of various wireless protocols, with a particular focus on their frequency hopping strategies, including, for example, the interaction between DECT and the Japanese Personal Handyphone System (PHS)
- one of the leaders of a global task force evaluating the technologies and business models for satellite networks, including major new networks such as Iridium, Globalstar, and Teledesic
- pioneered the first PDA with digital cellular connectivity (Apple Newton, Nokia Data Card and Nokia 2110) and collaborated with Nokia on the development and testing of the very first modern smartphone, the Nokia Communicator
- built the business from pre-launch through to profitability, which has now become the clear market leader and Vodafone's most successful business worldwide
- designed and drove a path-breaking multi-million-dollar global academic research program on the economics of communications, networks, and technologies in deregulated markets. Fellow participants included Jean-Jacques Laffont, Jean Tirole, Paul David, David Teece, David Gabel, and Glenn Woroch.

Boston Consulting Group

Manager

1991–1993

Michael focused on technology and telecoms businesses, including Philips Electronics, Telecom NZ, Telstra, and in particular BellSouth International. Responsible for training programs in advanced analytical techniques for strategy development.

Braxton Associates

Manager

1987–1991

Michael worked on a wide range of strategy projects, focusing on electronics and defense businesses in particular, such as companies involved in command and control systems, aircraft, tanks, submarines, and satellite networks. Also worked on corporate strategy, product development, manufacturing and operational transformation, and market entry. Played a leading role in development and training, focusing in particular on approaches to organizational transformation.

Mars Electronics

Project Manager, Program Manager

1984–1987

Michael worked as roboticist; cyberneticist; and designer, developer, and program manager for large-scale real-time systems for manufacturing and logistics. Involved in the development of overall business strategy.



Endeavour.Partners

16

June 2024

Michael A M Davies

Curriculum Vitae

Cookson Group

Robotics Engineer, Project Manager

1982–1984

Michael worked as a robotics engineer and automation manager overseeing and supporting many existing robotic handling and other automation systems. Designed, developed, and deployed additional state-of-the-art robotic and automation systems for manufacturing processes and material handling.

Academic Experience

Massachusetts Institute of Technology

Senior Lecturer—Integrated Design and Management

Michael was invited to create and teach, as part of Integrated Design Lab I and Integrated Design Lab II (EM.441 and EM.442), courses that present fundamentals of and advanced topics in integrated design and product development process.

Michael developed and taught fundamental concepts, including innovation, emerging technologies, product management, product marketing, basic finance and business models, and pricing and marketing. Developed and taught advanced topics, including competitive analysis and market opportunity identification, funding entrepreneurship, business plan and pitch, and data-driven decision-making.

Senior Lecturer—Engineering Systems Division (now Institute for Data, Systems, and Society)

Michael was responsible for creating, managing, and teaching two capstone leadership courses, the Systems Leadership & Management Lab (SL&M Lab) and Praxis (ESD.39 and ESD.S51).

SL&M Lab is a semester-long course in which System, Design, and Management (SDM) Fellows work at least one full day per week ("fifteen person-days) on average with the top management of a high-tech business on a relevant real-world systems and management challenge. The host companies set the focus; therefore, project teams work on problems of true concern to the host companies.

The course also focuses on challenges such as team roles, logical thinking and writing, and the use of graphical communication. Assignments can range from high-level systems thinking issues to building a prototype. SDM students take this experience with them as they work with their host companies or continue in their career progression and development.

The SL&M Praxis course is about praxis: practice—application or use of knowledge or skills—as distinguished from theory. The course gives SDM Fellows insights into the realities of decision-making and managerial behavior in large, complex, high-tech, and systems businesses. It provides students with systematic approaches to apply their systems, architecture, technology, and strategy learnings to real-world leadership and management challenges. This course runs during the summer session as a complement to and preparation for the SL&M Lab course.

Senior Lecturer—Bernard M. Gordon-MIT Engineering Leadership Program, School of Engineering

The Bernard M. Gordon-MIT Engineering Leadership Program (<http://web.mit.edu/gordonelp/>) fosters new approaches that prepare the nation's young engineering leaders for productive and effective careers in engineering companies, and continues MIT's rich, innovative tradition of engineering leadership.

Michael taught the capstone undergraduate leadership course, Engineering Leadership (ESD.045).

The Engineering Leadership course exposes students to the models and methods of engineering leadership within the contexts of conceiving, designing, implementing, and operating products, processes, and systems. In particular, taught the Engineering Systems elements of the course, homed within AeroAstro.

Michael taught the Technology & Strategy course (15.905/15.965).

Michael A M Davies

Curriculum Vitae

The Technology & Strategy course provides a strategic framework for managing high-tech businesses. It emphasizes the development and application of ways of thinking or mental models that bring clarity to the complex co-evolution of technological innovation, the demand opportunity, business ecosystems, decision-making, and execution within the business.

These tools help managers anticipate and decide how to respond to the behavior of competitors, complementors, and customers; and decide which technologies to invest in, opportunities to target, or partnerships to pursue.

Principal Investigator—Engineering Systems Division (now Institute for Data, Systems, and Society)

Involved in the research on the improvement of software project outcomes by attacking complexity and technical debt as part of a National Science Foundation (NSF) I-Corps program.

Researcher and Thesis Advisor

Supervises thesis work on related areas, including recent prize-winning work on the future of the smart grid, and theses on a broad range of issues.

Conducts research on how psychology shapes consumers' buying behavior and how product features and specifications influence consumers' choices among products and their liking for products. This culminated in a keynote presentation at MIT in Europe, held in Vienna, Austria and a keynote presentation at MIT in South America, held in Chile in 2023

London Business School

The Business of Artificial Intelligence

Course director for the highly rated flagship online program in how to create business value from Artificial Intelligence.

New Technologies Ventures Program

Manage and teach this unique program that brings MBAs and business students from London Business School together with post-doctoral researchers from University College London.

The goal of this course is to enable would-be entrepreneurs to evaluate novel ideas and inventions and turn them into new technology ventures. Participants, who are business professionals, scientists, engineers, and would-be entrepreneurs, explore how entrepreneurs and investors identify and analyze the feasibility of innovative technical ideas, turn them into products and services, and take these products and services to market, as both start-ups and established businesses. A key element of the program is projecting demand for innovative products and new product features