

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMAZON.COM, INC., AMAZON.COM SERVICES, LLC,
Petitioner

v.

NOKIA TECHNOLOGIES OY,
Patent Owner

Case: IPR2024-00691

U.S. Patent No. 8,050,321

DECLARATION OF DR. IAIN RICHARDSON

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	EDUCATIONAL BACKGROUND AND QUALIFICATIONS	2
III.	MATERIALS REVIEWED AND TIME OF INVENTION	5
IV.	LEGAL STANDARDS	5
1.	Overview	5
2.	Patent Claims.....	5
3.	Burden of Proof for Invalidity.....	7
4.	Claim Construction.....	7
5.	Person of Ordinary Skill in the Art	8
6.	Anticipation.....	8
7.	Obviousness.....	9
V.	PERSON OF ORDINARY SKILL IN THE ART (POSITA).....	12
VI.	CLAIM CONSTRUCTION.....	13
VII.	BACKGROUND	13
1.	The '321 Patent	18
2.	The Prior Art	19
a.	MPEG-1	19
b.	Kim.....	26
VIII.	The Grounds in the Petition do not anticipate or render obvious the Challenged claims.....	29
1.	Petitioner Has Not Established A Reasonable Likelihood That The Challenged Claims Are Unpatentable In Light Of Ground 1 (MPEG-1).....	29
a.	Petitioner fails to demonstrate that limitations 8[a], 10[a], and 11[a] are obvious over MPEG-1	29

b.	Petitioner fails to demonstrate that limitations 8[b], 10[b], and [11[b] are obvious over MPEG-1 for the same reasons as 8[a], 10[a], and 11[a]	36
c.	Petitioner fails to demonstrate that limitations 8[d], 10[d], and 11[d] are obvious over MPEG-1 because MPEG-1 does not teach or suggest resetting the identifier value as required	37
2.	Petitioner Has Not Established A Reasonable Likelihood That The Challenged Claims Are Unpatentable In Light Of Ground 2—Kim.	38
a.	Petitioner fails to demonstrate that limitations 8[a], 10[a], and 11[a] are obvious over Kim.....	38
b.	Petitioner fails to demonstrate that limitations 8[b], 10[b], and [11[b] are obvious over Kim for the same reasons as 8[a], 10[a], and 11[a].....	43
c.	Petitioner fails to demonstrate that limitations 8[d], 10[d], and 11[d] are obvious over Kim because Kim does not teach or suggest resetting the identifier value as required	44
3.	Petitioner Has Not Established A Reasonable Likelihood That The Challenged Claims Are Unpatentable In Light Of Ground 3.	45
a.	Petitioner fails to demonstrate that Claim 9 is obvious over MPEG-1 in combination with Yagasaki.....	45
IX.	SIGNATURE.....	47

I, Dr. Iain Richardson, declare as follows:

I. INTRODUCTION

1. I have been retained on behalf of Nokia Technologies OY and asked to provide opinions in respect of Inter Partes Review (IPR) proceeding IPR2024-00691 which relates to U.S. Patent No. 8,050,321, the ‘321 Patent.

2. This Declaration summarises the independent opinions that I have formed to date which are based on the material currently available to me. I reserve the right to modify my opinions, if necessary, based on further review and analysis of information that I receive subsequent to the filing of this Declaration, including in response to any positions taken by Petitioners or their experts that I have not been provided yet. I further understand that an institution decision is “all-or-nothing”, and so I have focused my opinions on the independent claim at issue in this petition, as well as the dependent claim but only to the extent it depends on the independent claim 8. Should the petition be instituted, I anticipate offering additional opinions regarding both the dependent and independent claims.

3. My findings, as explained below, are based on my study, experience, knowledge and background in the fields discussed below. I am informed by my education and my extensive experience in the fields of video compression and multimedia coding and communications. I have also relied on my review and

analysis of the prior art, information provided to me and information I have independently reviewed.

II. EDUCATIONAL BACKGROUND AND QUALIFICATIONS

4. Details of my professional qualifications and background are summarized below and are set out in detail in my Curriculum Vitae, attached to this declaration.

5. I am Director and co-founder of Vcodex BV.

6. I have over 30 years of experience related to video and image compression and coding. I am qualified by education and experience to testify as an expert with respect to subject matter in the fields of video, image, multimedia and general-purpose data encoding, decoding, compression, decompression, and transmission.

7. I received a Master of Engineering (M.Eng.) degree in Electronic and Electrical Engineering from Heriot-Watt University in Edinburgh, Scotland in 1990. I received a Doctor of Philosophy (Ph.D.) degree in Video Compression from Robert Gordon University in Aberdeen, Scotland in 1999. I worked as a Digital Signal Processing (“DSP”) Hardware Designer with GEC Avionics Ltd. from 1990 to 1993.

8. In 1993, I assumed a post as a Lecturer, then Reader and eventually a Full Professor in the field of image and video compression in the School of

Engineering at Robert Gordon University. In 2009, I was awarded the position of Honorary Professor with Robert Gordon University.

9. At Robert Gordon University, I founded and ran an image communication technology research laboratory. I carried out original research in the field of data, image, and video compression, initiated and managed research projects, and supervised research students.

10. I am the author of four books and over 70 journal and conference papers on video and image coding and communication, including two widely cited books on the H.264 / MPEG-4 industry standards for video compression. In my 2002 book, *Video Codec Design*, I discussed in detail the efficient implementation of image and video compression on software and hardware platforms.

11. In 1995, during my employment at Robert Gordon University, I co-founded and became Technical Director, equivalent of Chief Technology Officer, at 4i2i Communications Limited. I held this position until 2000. In my role at 4i2i, I was responsible for and engaged in the design of software and hardware modules for compression and communication systems. The designs included video processing algorithms in software and hardware for implementation on processing devices and the design of compression algorithms such as block-based transforms, run-length coding, and variable-length coding in software and hardware. A modified version of

one of my video compression hardware designs was successfully used by NASA to stream video from the International Space Station.

12. In 2007, I founded Vcodex Limited and currently serve as the CEO, through which I provide technical and strategic advice to technology companies particularly relating to video, image, and data compression for streaming.

13. In 2009, I founded Onecodec Limited and served as CEO, leading the company's development of innovative video, image, and multimedia data compression and storage software and systems. Onecodec's technology and business activities were merged with Vcodex Limited in 2015.

14. I have previously prepared expert reports and testified in a number of cases concerning video and image compression, graphics compression, general-purpose data compression, and multimedia streaming.

15. I am a named inventor on 11 patents or patent applications, including U.S. and non-US patents and applications.

16. Because of my background, training, and experience, I am qualified as an expert in the technical areas relevant to the '321 patent. My company Vcodex BV is being compensated for my independent analysis as an expert with respect to this inter partes review (IPR) proceeding, but neither my compensation nor Vcodex BV's compensation is contingent in any way on the content of my analysis or the outcome of this proceeding. I have no financial interest in Petitioner (Amazon.com, Inc.,

Amazon.com Services LLC) or Patent Owner (Nokia Technologies Oy) and I have no financial interest in the challenged patent.

III. MATERIALS REVIEWED AND TIME OF INVENTION

17. The opinions contained in this Declaration are based on the documents that I reviewed; the Petition (included all materials cited therein), my professional judgment, as well as my education, experience, and knowledge regarding technologies related to the '321 Patent.

IV. LEGAL STANDARDS

1. Overview

18. I am not an attorney or a legal expert, and I do not opine on matters of law. All the legal standards, which are listed in this section and which I applied in reaching the conclusions expressed throughout this Declaration, were provided to me and explained to me by counsel. In preparing this Declaration, I have endeavored to faithfully apply these legal standards. I do not intend to offer opinions on the law. Below, I describe the legal standards that I applied in analyzing the claims of the '321 Patent.

19. I have been informed by counsel that the challenger of a patent's validity bears the burden of proving invalidity of the patent.

2. Patent Claims

20. I have been informed by counsel that a patent's claims describe the

invention made by the inventors and describe what the patent owner owns and what the owner may prevent others from doing.

21. I have been informed by counsel that claims may describe products, such as machines or chemical compounds, or processes for making or using a product. Claims are usually divided into parts or steps called limitations.

22. I have been informed by counsel that there are two types of claims: independent claims and dependent claims. An independent claim sets forth all the requirements that must be met in order to be covered by that claim. Thus, it is not necessary to look at any other claim to determine what an independent claim covers. A dependent claim does not itself recite all of the requirements of the claim, but refers to another claim for some of its requirements. In this way, a dependent claim depends on another claim. The law considers a dependent claim to incorporate all of the requirements of the claims to which it refers.

23. I have been informed by counsel that that a dependent claim then adds its own additional requirements. To determine what a dependent claim covers, it is necessary to look at both the dependent claim and any other claims to which it refers.

24. I have been informed by counsel that in a case where a dependent claim incorporates the limitations of an independent claim upon which it depends, if a reference fails to disclose any of the limitations of the independent claim, the

claims which depend on that independent claim cannot be made invalid by such a reference. As a result, any of the references at issue in this proceeding that fail to disclose all of the limitations of an independent claim necessarily also fail to disclose all of the limitations of claims which depend on that independent claim.

3. Burden of Proof for Invalidity

25. I have been informed by counsel and I understand that the party challenging the validity of an issued U.S. patent in an IPR bears the burden of proving invalidity through facts supported by a preponderance of the evidence. I have been informed that a “preponderance of the evidence” means evidence sufficient to prove that a fact is more likely true than it is not. I understand that, for the determination of whether to institute an IPR, the challenger must show a reasonable likelihood of success in invalidating at least one challenged claim.

4. Claim Construction

26. I have been informed by counsel and I understand that the first step in determining validity is to properly construe the claims. I have further been informed by counsel that, in this proceeding, the Board must determine the scope of the claims by using the same claim construction standard that United States District Courts use. Under this standard, the words of a claim are given their “ordinary” and “customary” meaning as would have been understood by a person of ordinary skill in the art at the time of the invention. I have been informed that such a person looks to the claims,

specification, and file history in understanding the meaning of the claim terms. I have applied this understanding in this declaration.

5. Person of Ordinary Skill in the Art

27. I have been informed by counsel and I understand that a person having ordinary skill in the art may be defined by factors such as, when considered at the time of the alleged invention: (a) the levels of education and experience of the inventor and other persons actively involved in the field; (b) the types of problems encountered in the field; (c) prior art solutions to those problems; (d) rapidity with which innovations are made; and (e) the sophistication of the technology.

6. Anticipation

28. I have been informed by counsel and I understand that a patent claim can be found invalid as anticipated if each and every element of the claim, as properly construed, is found either explicitly or inherently in a single prior art reference. If the single prior art reference does not disclose explicitly or inherently any one claim limitation, then that claim is not anticipated. I have further been informed that the single prior art reference cannot merely disclose each element; rather, it must disclose all of the elements as arranged in the claim. I have been informed that for a prior art reference to “inherently” disclose something, the reference must necessarily function in accordance with, or include the claimed limitations, to anticipate. The missing descriptive matter cannot merely probably or

possibly include the claimed limitations. I have further been informed by counsel that, with respect to an anticipation analysis, it is improper to combine separate, distinct embodiments of a single prior art reference.

29. I have been informed that for a reference to be anticipatory, the reference must contain an enabling disclosure. I have been informed that merely naming or describing the subject matter is insufficient if it cannot be produced without undue experimentation.

7. Obviousness

30. I have been informed by counsel that a patent claim can be found invalid as obvious if the differences between the claim and the prior art references would have been obvious to a person of ordinary skill in the art at the time of the invention, taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any objective indicia of non-obviousness. I have further been informed by counsel that a claim can be found to be obvious in light of either a single prior art reference or multiple prior art references. I have been informed that references qualify as prior art for an obviousness determination only when they are analogous to the claimed invention. Two separate tests define the scope of analogous prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed; and (2) if the reference is not within the field of the inventor's endeavor,

whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved.

31. I have been informed that to be obvious in light of a single prior art reference or multiple prior art references, there must be a reason either to modify the single prior art reference or to combine the two or more prior art references to achieve the claimed invention. I have been informed by counsel that this reason may come from a teaching, suggestion, or motivation to combine which may come from the reference or references themselves, the knowledge or “common sense” of one skilled in the art, or from the nature of the problem to be solved, and may be explicit or implicit from the prior art as a whole.

32. I have been informed by counsel that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.

33. I have further been informed by counsel that there is no suggestion to combine, however, if a reference teaches away from its combination with another source. A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant, or if it suggests that the line of development flowing from the

reference's disclosure is unlikely to be productive of the result sought by the applicant. If, when combined, the references would produce a seemingly inoperative device, then they teach away from their combination. I have been informed that it is improper to combine references where the references teach away from their combination.

34. I have been informed by counsel that the degree of teaching away will depend on the particular facts; in general, a reference will teach away if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the applicant. I have been informed that a reference teaches away, for example, if (1) the combination would produce a seemingly inoperative device, or (2) the references leave the impression that the product would not have the property sought by the applicant.

35. I have been informed by counsel that if the teachings of a prior art reference would lead one skilled in the art to make a modification that would render another prior art device inoperable, then such a modification would generally not be obvious. I have been informed that if a proposed modification would render the prior art device unsatisfactory for its intended purpose, then the proposed modification would generally not be obvious.

36. I have been informed by counsel that it is improper to use hindsight in

making the obviousness determination.

37. I have been informed by counsel that some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness must be made. I have been informed that, for example, there may be no rational underpinning to support the legal conclusion of obviousness where systems are already complete and the party challenging validity seeks to mix and match components, which each exist in the separate systems, from these complete systems.

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

38. Based on my review of the Petition, I understand that Petitioner has identified that the POSITA “would have had a (1) Bachelor’s degree in electrical engineering, computer engineer, computer science, or a comparable field of study such as physics, and (2) approximately two to three years of practical experience with video encoding/decoding . . . [and] [a]dditional experience can substitute for the level of education, and vice-versa.” For the purposes of my analysis for this Declaration, I have used the definition that the Petitioner has identified, as it is my opinion that any potential differences of opinion I may have with Petitioner on the level of ordinary skill in the art is not material to the issues with their arguments.

39. All of my opinions in this Declaration are from the perspective of a person of ordinary skill in the art, as I have defined it above and during the relevant

time frame. During that time frame, I possessed at least the qualifications of a POSITA, as defined above.

VI. CLAIM CONSTRUCTION

40. I understand that claim terms are typically given their ordinary and customary meaning, as would have been understood by a person of ordinary skill in the art at the time of the alleged invention. In considering the meaning of the claims, I also understand that one must consider the claim language, specification, prosecution history, and the knowledge of a person of ordinary skill in the art at the relevant time.

VII. BACKGROUND

41. The advent and use of modern-day video coding and compression schemes involves a delicate balancing of competing concerns. On one hand, video technicians and consumers demand high fidelity and large resolution of video images to make use of large high definition displays and the wider availability of high-speed Internet connections. However, the competing concern becomes the efficient use of storage space on hard drives and memory cards as well as available bandwidth of Internet connections and computer processing demands. The use of modern video coding and compression schemes aim to represent video images in a compressed form with as little data as possible, while maintaining as much quality of the original source images as possible after decoding and ensuring the video image

can be decoded and displayed in real time. Present-day video coding often involves a trade-off between computation, compression and video quality. Increasing the amount by which data is compressed can save storage space and transmission bandwidth, but may result in degraded video quality to the point where the quality is unacceptably bad when viewed by the consumer. More compression for the same video quality, or better video quality for the same level of compression, may be achieved at the expense of increased computational processing.

42. Minimizing bitrate is extremely important for applications such as video streaming and various techniques have been developed to improve video compression (video encoding), such as techniques that take advantage of spatial redundancy (similarities between areas within a video frame, intra-frame techniques) and temporal redundancy (similarities between successive video frames, inter-frame techniques).

43. One such inter-frame technique, as recognized by the '321 Patent, is known as motion-compensated temporal prediction. '321 Patent, 2:15-17. It can be used to take advantage of the redundancy of successive image frames. '321 Patent, 2:15-17. In this method, a portion of a current frame to be encoded can be predicted from a portion in another, previously-encoded frame such as a past or future frame in display order. Motion-compensated temporal prediction attempts to identify a matching portion in a previously coded frame, which may be in a different position

due to motion of objects or areas, and to use this to predict a portion of a current frame. '321 Patent, 2:16-20. I-frames (or INTRA-frames) are encoded frames whose encoded image information was not determined using this motion-compensated temporal prediction process, while INTER-frames (also known as P-frames or B-frames) are encoded frames whose image information is, at least in part, determined based on prediction from one or more previously encoded frames in the sequence. Such previously encoded frames may be preceding frames in display order and/or subsequent frames in display order. A P-frame is encoded using only one previously encoded frame and a B-frame may be encoded using two previously-encoded frames, for example one preceding frame and one subsequent frame in display order. '321 Patent, 2:20-32, 2:42-47.

44. In prior art systems, the '321 Patent describes that “[t]o allow for flexible streaming of video files, many video coding systems employ scalable coding in which some elements or groups of elements of a video sequence can be removed without affecting the reconstruction of other parts of the video sequence.” '321 Patent, 3:3-7. By scalable coding, the '321 Patent refers to known video coding implementations that include “grouping the image frames into a number of hierarchical layers. The image frames coded into the “base layer” substantially comprise only the coded frames that are necessary for the successful decoding of the video information at the receiving end. The base layer of each group of pictures

(“GOP”) thus comprises one I-frame and a certain number of P-frames and/or B-frames. One or more enhancement layers can be determined that build upon the base layer, each one of the layers improving the quality of the video coding in comparison with an upper layer.” ’321 Patent, 3:7-20. That is, each layer, aside from the base layer, can be included or not based on bandwidth concerns or picture quality requirements or some balance thereof.

45. In prior art such as the MPEG-1 Video standard (Ex. 1005, “MPEG-1”), a Group of Pictures (GOP) is “a series of ... coded pictures intended to assist random access. The group of pictures is one of the layers in the coding syntax.” (Ex. 1005 at 23). Ex. 1005 defines a syntax for a coded video bitstream, comprising a set of layers (note: these are distinct from the ‘hierarchical layers’ discussed above with respect to scalable coding). These layers include the topmost or Video Sequence Layer, which includes coded syntax elements describing the entire coded video bitstream, the Group of Pictures Layer, which includes syntax elements that relate to an entire GOP, the Picture Layer, which includes syntax elements that relate to a single coded video frame or picture, and the Slice Layer, which includes syntax elements that relate to a slice, which is a portion of a coded picture (Ex. 1005 at 35-40).

46. In MPEG-1, a group of pictures is “a set of coded pictures which are contiguous in display order [and which] must contain at least one I-picture [intra

coded picture” (Ex. 1005 at 84). A series of GOPs are illustrated, with regard to MPEG-1 below. EX1005 at 32.

At the encoder input,

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
I	B	B	P	B	B	P	B	B	I	B	B	P	B	B	P	B	B	I	B	B	P	B	B	P

47. In the above illustration, the double vertical bars denote the group of pictures boundaries. EX1005 at 32. “Note that in this example, the first group of pictures is two pictures shorter than subsequent groups of pictures, since at the beginning of video coding there are no B-pictures preceding the first I-Picture. However, in general, in display order, there may be B-Pictures preceding the first I-Picture in the group of pictures, even for the first group of pictures to be decoded.” EX1005 at 32.

48. While these prior art methods improved aspects of video streaming, including bitrate efficiency, problems still existed. For example, some video coding standards such as the H.263 standard support a process known as Reference Picture Selection, in which it is possible to predict part of a current picture from a previously coded picture that is not the immediately preceding I- or P-picture. 321 Patent, 3:37-43. In such a case, as “it is possible to also select[] at least one image preceding an I-image that begins a group of picture GOP as the reference image, a group of pictures employing reference picture selection cannot necessarily be decoded independent.” ’321 Patent, 3:44-56. In other words, when a process such as

Reference Picture Selection is employed, it is not guaranteed that a decoder can begin decoding independently from an I-picture that is located at or near the start of a GOP. The aforementioned scalability improvements presented further problems, as “the adjusting of scalability or coding method in the streaming server or a network element becomes difficult, because the video sequence must be decoded, parsed, and buffered for a long period of time to allow any dependencies between different image groups to be detected.” ’321 Patent, 3:55-61.

49. Another problem arises “relate[d] to detection of image frames from which a decoder can start the decoding process. The detection is useful for multiple purposes. For example, an end-user may wish to start browsing a video file from the middle of a video sequence. Another example relates to starting the reception of a broadcast or multicast video transmission from the middle of the video transmission. A third example relates to on-demand streaming from a server and occurs when an end-user wishes to start playback from a certain position of a stream.” ’321 Patent 3:62-4:5. It is therefore important to be capable of identifying a coded video frame (picture) from which it is guaranteed that a decoder can begin decoding independently, for example to enable playback from or seeking to a particular position in a coded video stream (random access).

1. The ’321 Patent

50. The ’321 Patent claims an improved method “that enable[s] detection

of image frames from which a decoder can start the decoding process.” ’321 Patent, 4:8-10. “The invention is based on the idea of encoding a video sequence comprising an independent sequence of image frames, wherein at least one reference picture is predictable from at least one previous image frame that is earlier than the previous reference image frame in decoding order.” ’321 Patent, 4:16-20. The idea behind the ’321 Patent’s invention was to be able to identify during decoding of a bitstream an initiation picture among a series of pictures in an independently decodable sequence; and thus during the decoding process, any picture before the initiation picture is discarded, by being defined as unusable as a reference picture. *See* ’321 Patent, 4:31-35.

2. The Prior Art

a. MPEG-1

51. MPEG-1 Video ((ISO/IEC 11172-2, “MPEG-1”) is a standard developed by the Moving Pictures Expert Group, a subgroup of the ISO/IEC standardization body, that was approved in 1993. MPEG-1 specifies an encoded bitstream syntax, i.e. the structure of a bitstream that represents a compressed video sequence, and a method of decoding such a bitstream. MPEG-1 uses the term ‘picture’ to describe a single coded video frame or video image.

52. Several properties of groups of pictures in MPEG-1 are important with respect to the petition and its arguments. MPEG-1 defines a Group of Pictures or

GOP as per below:

D.5.2 Group of pictures

Two distinct picture orderings exist, the display order and the bitstream order (as they appear in the video bitstream). A group of pictures (gop) is a set of pictures which are contiguous in display order. A group of pictures must contain at least one I-picture. This required picture may be followed by any number of I and P-pictures. Any number of B-pictures may be interspersed between each pair of I or P-pictures, and may also precede the first I-picture.

Property 1. A group of pictures, in bitstream order, must start with an I-picture and may be followed by any number of I, P or B-pictures in any order.

Property 2. Another property of a group of pictures is that it must begin, in display order, with an I or a B-picture, and must end with an I or a P-picture. The smallest group of pictures consists of a single I-picture, whereas the largest size is unlimited.

The original concept of a group of pictures was a set of pictures that could be coded and displayed independently of any other group. In the final version of this part of ISO/IEC 11172 this is not always true, and any B-pictures preceding (in display order) the first I-picture in a group may require the last picture in the previous group in order to be decoded. Nevertheless encoders can still construct groups of pictures which are independent of one another. One way to do this is to omit any B-pictures preceding the first I-picture. Another way is to allow such B-pictures, but to code them using only backward motion compensation.

Property 3. From a coding point of view, a concisely stated property is that a group of pictures begins with a group of pictures header, and either ends at the next group of pictures header or at the next sequence header or at the end of sequence, whichever comes first.

Some examples of groups of pictures are given below:

```

I
I P P
I B P B P
B B I B P B P
B B I B B P B B P B B P
B I B B B B P B I B B I I
```

Figure D.17 -- Examples of groups of pictures in display order

These examples illustrate what is possible, and do not constitute a suggestion for structures of groups of pictures.

EX1005, 84-85 (Explaining and providing examples of Group of Pictures for MPEG-1).

53. One important aspect of MPEG-1 related to Petitioner's arguments is MPEG-1's "closed_gop flag." MPEG-1's closed_gop flag is part of the "Group of Pictures layer," i.e. it is part of the syntax layer that applies to an entire GOP, MPEG-1 at 2.4.2.4 ("Group of pictures layer").

closed_gop -- This is a one-bit flag which may be set to "1" if the group of pictures has been encoded without motion vectors pointing to the previous group of pictures.

54. As specified MPEG-1, when decoding an MPEG-1 video bitstream, the closed_gop flag is received in the group of pictures header. MPEG-1 defines “Closed GOPs” or “closed groups [of pictures]” as follows:

Closed GOP

A one bit flag follows the time code. It denotes whether the group of pictures is open or closed. Closed groups can be decoded without using decoded pictures of the previous group for motion compensation, whereas open groups require such pictures to be available.

A typical example of a closed group is shown in figure D.18a.

I	B	B	P	B	B	P	B	B	P	B	B	P
0	1	2	3	4	5	6	7	8	9	10	11	12

(a) closed group

B	B	I	B	B	P	B	B	P	B	B	P	B	B	P
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

(b) open or closed group

Figure D.18 -- Example groups of pictures in display order

A less typical example of a closed group is shown in figure D.18b. In this example, the B-pictures which precede the first I-picture must use backward motion compensation only, i.e. any motion compensation must be based only on picture number 2 in the group.

If the closed_gop flag is set to 0 then the group is open. The first B-pictures that precede the first I-picture in the group may have been encoded using the last picture in the previous group for motion compensation.

MPEG-1 at D.5.2 (“Group of pictures”).

55. The “one bit flag” referred to is the closed_gop flag. As the closed_gop flag is a flag in the group of pictures header, it is a syntax element that applies to an entire GOP and not any one specific coded frame. The closed_gop flag is therefore not an indication of any specific image frame.

56. For example, in Figure D.18 above, the value of the closed_gop flag (0 or 1) defines a property of the entire GOP, such as the 13-picture GOP shown in

Fig. D.18a or the 15-picture GOP shown in Fig. D.18b. More specifically, as the cited text above explains, the value of `closed_gop` defines certain properties of the coding of certain B-pictures in the GOP, namely whether or not B-pictures preceding the first I-picture may or may not use forward motion compensation (i.e. motion compensation from the preceding P- or I-picture).

57. In contrast, other syntax elements in an MPEG-1 video bitstream pertain to a specific coded picture, namely syntax elements found at the Picture Layer and lower syntax layers. MPEG-1 specifies that “The picture layer contains all the coded information for one picture”. Ex. 1005 at 87.

58. Thus, the `closed_gop` flag is not an indication of an image frame in the GOP and at most, indicates certain properties of certain B-pictures in the GOP. As shown in Figure D.18 above, a `closed_gop` flag does not indicate any particular image frame and does not pertain to any particular image frame.

59. Another aspect of MPEG-1 that is important with respect to Petitioner’s argument is “Temporal Reference,” encoded as a syntax element `temporal_reference` that is part of the Picture Layer syntax, i.e. unlike the `closed_gop` flag, `temporal_reference` is a syntax element that is associated with a specific coded picture (Ex. 1005 at 38).

60. MPEG-1 explains that “Temporal Reference” can be used to define

“the order in which the pictures must be displayed.” For a given group of pictures (whether open or closed), the first picture in display order has a Temporal Reference of zero:¹

D.5.3.2 Temporal reference

The Temporal Reference is a ten-bit number which can be used to define the order in which the pictures must be displayed. It may be useful since pictures are not transmitted in display order, but rather in the order which the decoder needs to decode them. The first picture, in display order, in each group must have Temporal Reference equal to zero. This is incremented by one for each picture in the group.

Some example groups of pictures with their Temporal Reference numbers are given below:

Example (a) in display order	I	B	P	B	P								
	0	1	2	3	4								
Example (a) in decoding order	I	P	B	P	B								
	0	2	1	4	3								
Example (b) in display order	B	B	I	B	B	P	B	B	P	B	B	P	
	0	1	2	3	4	5	6	7	8	9	10	11	
Example (b) in coded order	I	B	B	P	B	B	P	B	B	P	B	B	
	2	0	1	5	3	4	8	6	7	11	9	10	
Example (c) in display order	B	I	B	B	B	B	P	B	I	B	B	I	I
	0	1	2	3	4	5	6	7	8	9	10	11	12
Example (c) in coded order	I	B	P	B	B	B	B	I	B	I	B	B	I
	1	0	6	2	3	4	5	8	7	11	9	10	12

Figure D.19 -- Examples of groups of pictures and temporal references

EX1005, 87-88.

61. In an MPEG-1 coded video bitstream, the order in which pictures must be displayed (the display order) is in general different from the “coded order” of the pictures, which defines the order that the pictures are decoded. As illustrated in Figure D.19, the coded order for a picture can be and typically is different from the

¹ Temporal reference is also set to zero when there are more than 1024 pictures in a GOP. EX1005, 87. This is a limitation of the number of bits used to express temporal_reference in the coded video bitstream.

temporal order.

62. Petitioner identifies one example in MPEG-1 and refers to it as an “Exemplary Closed GOP.” Pet. 16-18. This so-called “Exemplary Closed GOP” is the crux of what Petitioner bases Petitioner’s arguments upon.

63. Ignoring the entirety of Figure D.18 of MPEG-1, Petitioner, and its expert, focus solely on what MPEG-1 describes as one “typical example” shown in Fig. D.18(a), ignoring the remainder of Fig. D.18 and the associated text and ignoring multiple other examples in MPEG-1. EX1005, 86. As part of Petitioner’s reliance on its so-called “Exemplary Closed GOP” from Figure D.18(a), Petitioner appears to contradict the information that `closed_gop` flag actually conveys according to MPEG-1 (i.e., “whether the group of pictures is open or closed,” EX1005, 86) with a particular circumstance illustrated by Figure D.18 that goes beyond the information `closed_gop` flag conveys.

64. Specifically, Petitioner argues that a “a key feature of this exemplary closed GOP is a single I-picture **must** be the first picture of the GOP in both decoding order and display order and **must** have a Temporal Reference of zero.” Pet. 17, emphasis added. But these are not requirements imposed by MPEG-1 and are not required by a particular setting of a `closed_gop` flag. Rather, these circumstances merely reflect one “[e]xample group[] of pictures in display order.”

EX1005, 86.

65. Below is the entire Fig. D.18.

Closed GOP

A one bit flag follows the time code. It denotes whether the group of pictures is open or closed. Closed groups can be decoded without using decoded pictures of the previous group for motion compensation, whereas open groups require such pictures to be available.

A typical example of a closed group is shown in figure D.18a.

I	B	B	P	B	B	P	B	B	P	B	B	P
0	1	2	3	4	5	6	7	8	9	10	11	12

(a) closed group

B	B	I	B	B	P	B	B	P	B	B	P	B	B	P
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

(b) open or closed group

Figure D.18 -- Example groups of pictures in display order

A less typical example of a closed group is shown in figure D.18b. In this example, the B-pictures which precede the first I-picture must use backward motion compensation only, i.e. any motion compensation must be based only on picture number 2 in the group.

If the closed_gop flag is set to 0 then the group is open. The first B-pictures that precede the first I-picture in the group may have been encoded using the last picture in the previous group for motion compensation.

66. Fig. D.18 shows that for D.18(b), described as an “open *or closed* group [of pictures],” the I-frame is **not** the first frame in display order. The example of D.18(b) shows that the first coded pictures or frames in a closed GOP, in display order, may be B-pictures. EX1005, 86.

67. Petitioner and its expert appear to acknowledge this, noting that the I-frame is only first in its so-called “Exemplary Closed GOP” because “**the example** specifies that any B-pictures preceding the first I-picture have been omitted.” Pet. 17, emphasis added.

68. Further, in Petitioner’s so-called “Exemplary Closed GOP”, there is—

coincidentally—only one I-frame. Pet. 17. Yet, other well-known examples of GOPs disclosed in MPEG-1 have more than one I-frame. Figure D.17 makes this clear:

Some examples of groups of pictures are given below:

```

I
I  P  P
I  B  P  B  P
B  B  I  B  P  B  P
B  B  I  B  B  P  B  B  P  B  B  P
B  I  B  B  B  B  P  B  I  B  B  I  I

```

Figure D.17 -- Examples of groups of pictures in display order

EX1005, 85.

69. Well-known examples of GOPs containing multiple I-frames, such as the final example of Figure D.17 above, illustrate the fact that the `closed_gop` flag is not an indication of an image frame, as it cannot and does not indicate by itself which of the multiple I-frames in the GOP is the “first image frame, in decoding order, of an independent sequence” as required by the ’321 patent claims.

b. Kim

70. Kim is directed to a Time Lapse recording/reproduction device and method. Specifically, Kim describes recording, compressing and reproducing intermittently recorded image data. Examples of where this type of technology is applied is in banks or other security-sensitive areas; in such implementations, pictures may be recorded intermittently and then stored in a database. These individual images can be reproduced when needed.

71. Petitioner relies heavily on Figure 5A of Kim. Kim describes FIGs. 5A and 5B as illustrating “examples of a logical data structure of a digital data stream compressed and recorded on the optical disk according to [Kim’s] present invention.”

72. According to Kim, in FIG. 5A, each “P-picture frame P1, P2, P3 has a current address (“CAD”) indicating the current address of the P-picture, and an I-picture reference address (“IAD”) indicating the address of the corresponding (or previous) I-frame.” Kim at 4:46-52 (shown below)

The bit stream generated and transmitted to the recording/
reproducing unit 140 as described above has a logical
structure as shown in, e.g., FIG. 5A. As shown therein, each
P-picture frame P1, P2, P3 has a current address CAD
50 indicating the current address of the P-picture, and an
I-picture reference address IAD indicating the address of the
corresponding (or previous) I-frame. If image signals are

73. Petitioner relies on FIG. 5A and Kim at 4:46-52 to show “an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence, wherein all motion-compensated temporal prediction references of the independent sequence refer only to image frames within said independent sequence.” Petition at 46.

74. In my opinion, Petitioner is incorrect to suggest that FIG. 5A and 4:46-52 of Kim show the claimed “indication”. Petitioner points to an IAD of 0000 as the claimed “indication” and argues FIG. 5A discloses an independent sequence because

coincidentally the P pictures in FIG. 5A refer to the first I frame. As with MPEG-1, Petitioner relies on what in my opinion is the circumstance of a specific example, not the actual teaching of Kim, to infer the “indication” claim limitation. In Kim’s method, the IAD address for an I-picture is “zero or absent” and Kim discloses it as such referring to Fig. 6.

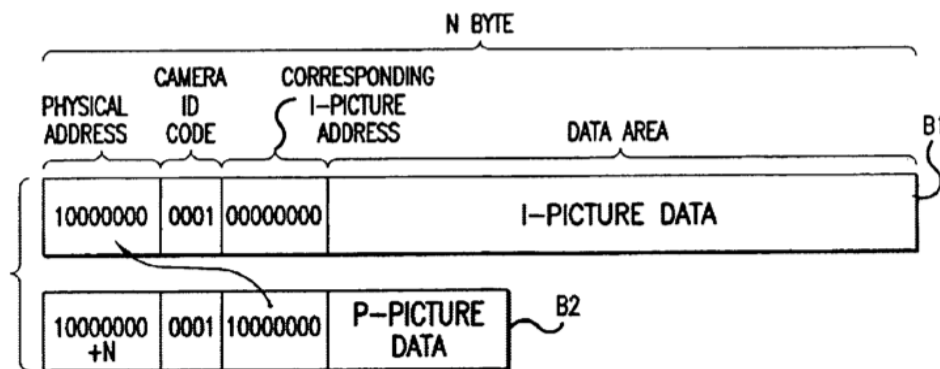


FIG.6

75. Since an I-picture does not require a reference to another I-picture, the field can be “zero or absent” and a POSITA reading the disclosure would understand that the field could take any value. Kim, 4:66-5:1.

76. As the IAD field for an I-picture can be “zero or absent” in Kim, it does not have any functional use and therefore a POSITA would recognize that it is not disclosed as an indication that is “decoded from [a] video sequence”. I note that the only support for Petitioner’s statement that “A POSITA would have understood that decoding the bitstream in Figure 5A would include decoding... the IAD values” (Petition at 47) is Dr Havlicek’s statement that “Kim ... explains the process for

decoding this bitstream”, referring to Kim at 5:8-6:8 and Fig. 4 (Ex. 1003 at 152-154). However, Kim Fig. 4 and 5:8-6:8 says nothing about decoding or even detecting the IAD field for an I-picture. Thus I see no independent support for Petitioner’s statement.

VIII. THE GROUNDS IN THE PETITION DO NOT ANTICIPATE OR RENDER OBVIOUS THE CHALLENGED CLAIMS

1. Petitioner Has Not Established A Reasonable Likelihood That The Challenged Claims Are Unpatentable In Light Of Ground 1 (MPEG-1).

a. Petitioner fails to demonstrate that limitations 8[a], 10[a], and 11[a] are obvious over MPEG-1

77. Each of limitations 8[a], 10[a], and 11[a] are written with similar language and require “[decoding/decode] from the video sequence an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence, wherein all motion-compensated temporal prediction references of the independent sequence refer only to image frames within said independent sequence,” and thus I analyze them here together.

78. It is my opinion that Petitioner² has failed to show that MPEG-1

² Because Petitioner submitted an expert declaration that in my opinion is substantively identical to the limitation by limitation analysis, when I refer to Petitioner in these claim sections, I refer to both Petitioner’s argument and the substantively identical expert declaration substance.

teaches or suggests these limitations.

79. In this Ground, Petitioner asserts two distinct arguments as to how the “[decoding/decode] from the video sequence an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence limitations” is taught or suggested—pointing to MPEG-1’s closed GOP or, alternatively, to MPEG-1’s Temporal Reference.

80. *First*, Petitioner first asserts that MPEG-1’s closed_gop teaches or suggests “[decoding/decode] from the video sequence an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence.” Petitioner’s assertion is in my opinion incorrect.

81. As an initial matter, MPEG-1’s closed GOP flag closed_gop, signalled in the GOP header, is only an indication of whether or not a group of pictures is open or closed. This flag does not indicate an I-frame, nor does it identify an I-frame. EX1005, 37. As I explained earlier, the closed_gop flag is signalled in an MPEG-1 video bitstream at a particular syntax layer, the Group of pictures layer, that is related to an entire GOP and is not specific to any particular frame:

0.5 Structure of the coded video bitstream

This part of ISO/IEC 11172 specifies a syntax for a coded video bitstream. This syntax contains six layers, each of which either supports a signal processing or a system function:

Layers of the syntax	Function
Sequence layer	Random access unit: context
Group of pictures layer	Random access unit: video
Picture layer	Primary coding unit
Slice layer	Resynchronization unit
Macroblock layer	Motion compensation unit
Block layer	DCT unit

EX1005, 16;

82. Syntax elements signalled in the GOP layer apply to an entire GOP, i.e. a collection of coded pictures defined by MPEG-1, as distinct for example from syntax elements in the Picture layer which apply to a specific coded picture. Thus when a decoder processes the bitstream and decodes the syntax element `closed_gop`, it does not decode an indication of, or relating to, any particular coded frame, but instead decodes information that pertains to an entire GOP. For this reason alone, `closed_gop` does not and cannot indicate a first image frame (or indeed any specific coded frame) in an independent sequence or in a coded video sequence.

83. Further, the `closed_gop` flag cannot be used inherently to determine a particular I-picture, or any specific coded frame or picture, in an independently decodable group of pictures. MPEG-1 places no constraint on the number of I-pictures in a GOP and provides specific examples of GOPs containing multiple I-pictures. As Group of Picture Layer syntax elements apply to the entire GOP, a flag such as `closed_gop` does not identify or apply to any one particular I-picture as asserted by Petitioner.

84. The Figures and examples in MPEG-1 illustrate that a wide variation in GOP sizes and structures is possible, such that for example there may be a varying number of I pictures in GOPs that conform to MPEG-1:

Some examples of groups of pictures are given below:

```

I
I  P  P
I  B  P  B  P
B  B  I  B  P  B  P
B  B  I  B  B  P  B  B  P  B  B  P
B  I  B  B  B  B  P  B  I  B  B  I  I

```

Figure D.17 -- Examples of groups of pictures in display order

EX1005, 85.

85. Thus, while the closed_GOP flag can indicate whether or not the GOP is closed, it does not identify or indicate an I-picture in the GOP that is the first image, in decoding order, of that group of pictures.

86. The “idea of the [’321 Patent’s] invention” “is to determine an initiation picture in an independently decodable group of pictures, whereby in the decoding phase any picture prior to said initiation picture is defined as unusable for reference.” ’321 Patent, 4:31-38. Were a video codec to fail to determine such an initiation picture, the scalability and random access benefits described by the ’321 Patent would not be achieved.

87. For example, according to the ’321 Patent, SI pictures can be used to allow random access into what in MPEG-1 terms would be a closed group of pictures. Absent the indication provided by the ’321 Patent indicating a specific

coded *frame*, rather than indicating or providing information about a Group of Pictures, a decoder would not be able to recognize the SI frame types (among others) in order to achieved its intended random access, subsequences, or other scalability benefits. '321 Patent, 9:54-10:23.

88. ***Second***, Petitioner points to MPEG-1's Temporal Reference of zero and asserts that this teaches "decoding from the video sequence an indication of at least one image frame, which is the first image frame, in decoding order, of [the] independent sequence." Pet. 23-24. Relying on its so-called "Exemplary Closed GOP," Petitioner asserts that "the first picture in decoding order of the *exemplary* closed GOP will always be an I-frame with a Temporal Reference of zero". *Id.* (emphasis added).

89. The problem with Petitioner's argument, however, is that it relies on its so-called "*exemplary* closed GOP." *Id.* (emphasis added). In other words, the Petition relies on coincidence rather than any specific indication relating to a coded image frame (such as an indication *of* at least one image frame, which is the first image frame, in decoding order, of [the] independent sequence). It is not true that a closed GOP *must* have a first picture in decoding order that is an "I-frame with a Temporal Reference of zero" as the Petition suggests. Neither the closed_gop flag nor Temporal Reference syntax elements indicate any such relationship.

90. For example, Figure D.19 shows instances where an I-picture is not the first image in display order. Examples (b) and (c) each have a B-picture as the first image in display order:

D.5.3.2 Temporal reference

The Temporal Reference is a ten-bit number which can be used to define the order in which the pictures must be displayed. It may be useful since pictures are not transmitted in display order, but rather in the order which the decoder needs to decode them. The first picture, in display order, in each group must have Temporal Reference equal to zero. This is incremented by one for each picture in the group.

Some example groups of pictures with their Temporal Reference numbers are given below:

Example (a) in display order	I	B	P	B	P								
	0	1	2	3	4								
Example (a) in decoding order	I	P	B	P	B								
	0	2	1	4	3								
Example (b) in display order	B	B	I	B	B	P	B	B	P	B	B	P	
	0	1	2	3	4	5	6	7	8	9	10	11	
Example (b) in coded order	I	B	B	P	B	B	P	B	B	P	B	B	
	2	0	1	5	3	4	8	6	7	11	9	10	
Example (c) in display order	B	I	B	B	B	B	P	B	I	B	B	I	I
	0	1	2	3	4	5	6	7	8	9	10	11	12
Example (c) in coded order	I	B	P	B	B	B	B	I	B	I	B	B	I
	1	0	6	2	3	4	5	8	7	11	9	10	12

Figure D.19 -- Examples of groups of pictures and temporal references

EX1005, 87.

91. Two simple counter-arguments show the error in Petitioner's argument. First, consider Fig. D.18b, which MPEG-1 discloses may describe an "open or closed GOP". This MPEG-1 example may be a closed GOP and begins with two B-pictures. Thus the first coded picture in display order, with a Temporal Reference of 0, is in this case a B-picture. As MPEG-1 specifies (p84), the first coded picture in a GOP in bitstream (i.e. decoding) order is an I-picture. Thus in the D.18b example, a Temporal Reference of 0 does not indicate "the first image frame, in decoding order" of the GOP, let alone of an independent sequence. In the D.18b

example, the first coded image frame in decoding order is the I-picture with display order 2 and therefore with Temporal Reference of 2.

92. The examples of Fig. D.19 further illustrate the flaw in Petitioner's argument. Out of the three examples, only Example (a) has the property that the picture with Temporal Reference 0 happens to be an I-picture. Examples (b) and (c) start with a B-picture in display order, so that the first I-picture in decoding order ("coded order") has a Temporal Reference of 2 or 1 respectively. Thus out of the five examples across both of Figs. D.18 and D.19, only **two** illustrate GOPs in which Temporal Reference of the first I-picture happens to be 0 and **three** show GOPs where the Temporal Reference of the first I-picture is **not** 0.

93. Second, MPEG-1 explains that the Temporal Reference may be reset to zero in a large GOP, whenever Temporal Reference exceeds 1023. Figure D.20 illustrates an example of just such a GOP (Ex. 1005 at 87).

94. Thus Temporal Reference is not and cannot be "an indication of a first image frame in decoding order of an independent sequence". In an MPEG-1 GOP, whether or not the first frame of a GOP in decoding order (which is always an I-picture) has a Temporal Reference of 0 is mere coincidence.

95. In the "Exemplary Closed GOP," Petitioner has constructed a case such that the I-picture is coincidentally the first image in display order, and then

relied on it being the first image in display order (hence a Temporal Reference of zero) to show that an I-picture is the first image in display order—a circular argument that results from its use of a so-called “exemplary closed GOP”. But Temporal Reference is just that—a reference for *display order*. Even though display order and decoding order may at times incidentally coincide with one another, such events are not a rule taught by MPEG-1 and are certainly not a requirement of MPEG-1.

96. It is my opinion that Petitioner has failed to show that MPEG-1 teaches or suggests the [a] limitations.

b. Petitioner fails to demonstrate that limitations 8[b], 10[b], and 11[b] are obvious over MPEG-1 for the same reasons as 8[a], 10[a], and 11[a]

97. Each of limitations 8[b], 10[b], and 11[b] are written with similar language and require “indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence” as with 8[a], 10[a], and 11[a].

98. As I discussed above in VIII.1.a, MPEG-1 does not teach or suggest the “indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence” as the claim requires. Thus, MPEG-1 does not teach or suggest starting the decoding of the video sequence from the “first image frame” of the independent sequence under either of the two aforementioned

theories Petitioner and Dr. Havlicek assert for the “indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence.”

c. Petitioner fails to demonstrate that limitations 8[d], 10[d], and 11[d] are obvious over MPEG-1 because MPEG-1 does not teach or suggest resetting the identifier value as required

99. Each of limitations 8[d], 10[d], and 11[d] are written with similar language and require “[resetting/reset] the identifier value for the indicated first image frame of the independent sequence,” and I analyze them together here. It is my opinion that Petitioner has failed to show that MPEG-1 teaches or suggests these [d] limitations.

100. While alternatively pointing to the Temporal Reference as an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence, Petitioner also asserts that Temporal Reference teaches or suggests the “resetting the identifier value for the indicated first image frame of the independent sequence.” In my opinion, Petitioner is incorrect in its assertion for at least the following reasons.

101. Petitioner once again relies upon its so-called “Exemplary Closed GOP” and ignores the full disclosure of MPEG-1. For Petitioner to make its argument, it has to show that the Temporal Reference must be set to zero for the

indicated first image frame of the independent sequence. But, as shown above VIII.1.a, MPEG-1 does not require that a first I-frame in a GOP always has a temporal reference of zero, and as a result there can be no “resetting” of an identifier value (see Fig. D.18(b), showing B-frames with Temporal Reference values of 0 and 1, while the first I-frame has a Temporal Reference of 2).

102. Additionally, Petitioner’s so-called “Exemplary Closed GOP” excludes the case where there are multiple I-frames in a closed GOP. In such an instance it could be that an I-frame after the first one (if that first one also coincidentally was the first frame in display order), would be the first I-frame to be decoded, but it would not have a Temporal Reference of zero, and thus there would not be a “reset.”

103. Thus, it is my opinion that the Petition has failed to show a reasonable likelihood of success in challenging the claims for this limitation.

2. Petitioner Has Not Established A Reasonable Likelihood That The Challenged Claims Are Unpatentable In Light Of Ground 2—Kim.

a. Petitioner fails to demonstrate that limitations 8[a], 10[a], and 11[a] are obvious over Kim

104. Each of limitations 8[a], 10[a], and 11[a] are written with similar language and require “[decoding/decode] from the video sequence an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence, wherein all motion-compensated temporal prediction

references of the independent sequence refer only to image frames within said independent sequence,” and so I analyze them together here. It is my opinion that Petitioner has failed to show that Kim teaches or suggests these [a] limitations.

105. Petitioner points to Figure 5A of Kim as “show[ing] the recited “indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence.” Pet. 44. Specifically, Petitioner states that “Kim also teaches the recited ‘indication’” because “in Kim’s Figure 5A, an IAD of 0000 or zero is ‘an indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence.’” I disagree, as Kim’s IAD of 0000 is merely an incidental property of the frame being an I-frame, as I explained earlier. Kim makes it clear that the “address of the corresponding I-picture frame”, i.e. the IAD field, is “zero or absent” in an I-picture frame (Kim 4:65-5:1), which makes sense because Kim’s I-picture frames **do not have** a “corresponding I-picture frame”, as they do not require any other frame for successful decoding (Kim 5:66-6:3). Thus an IAD of 0000 in Kim does not indicate anything at all and is not used by Kim’s reproducing method (it may be “zero or absent” because it is not required or used). This is supported by Kim Fig. 4 and accompanying description, wherein there is a step S34 for detecting the address of the corresponding I-frame (i.e. the IAD field), executed if the requested frame is a P-picture, but **no** corresponding step for detecting the address of a corresponding I-frame (the IAD field) if the requested

frame is an I-picture. Thus an IAD of 0000 in Kim, which is only present in the IAD field of an I-picture, is **not** detected, read or decoded by Kim's method and thus cannot be the claimed "indication of at least one image frame" that is "decod[ed] from the video sequence."

106. Petitioner attempts to explain this away by arguing that "[b]ecause each I-picture starts an independent sequence, the IAD of 0000 or zero indicates that a given picture starts an independent sequence." This is inconsistent with Figure 5B, which shows three I-frames in decoding order in a row, followed by three p-frames each depending on a different I-frame:

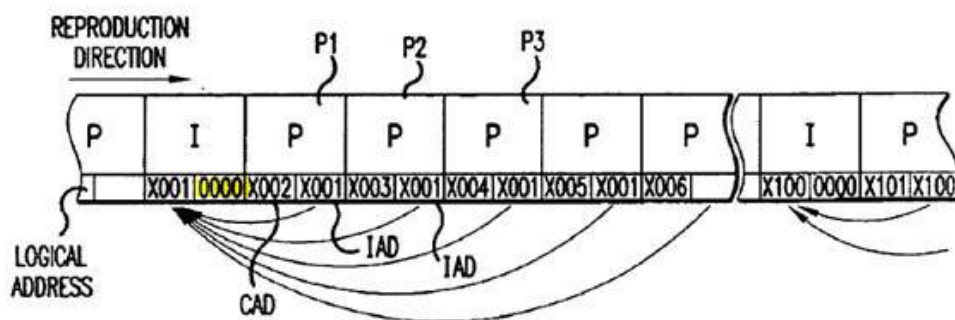


FIG.5A

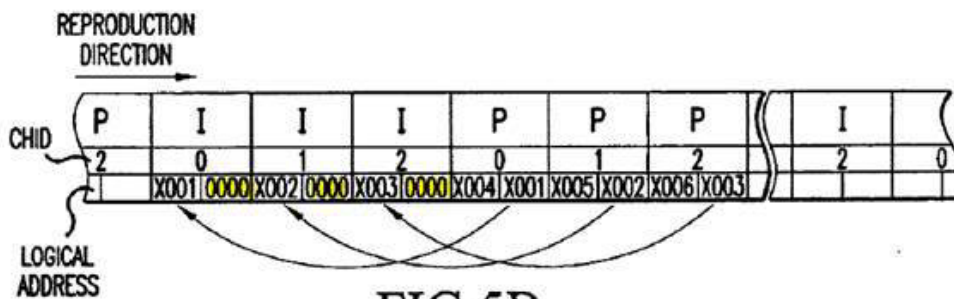


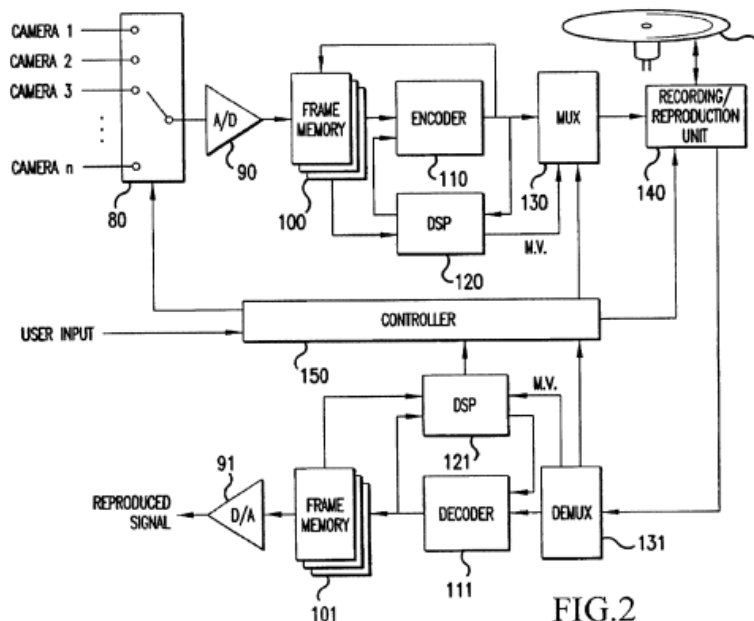
FIG.5B

Kim, Fig. 5.

107. Thus, while Figure 5A coincidentally has an image in which an I-frame begins a sequence followed by P-frames, the full disclosure of Kim does not support Petitioner's interpretation.

108. Further, Petitioner fails to recognize that Kim confirms that these IAD values are not decoded by the decoder at all. In Petitioner's argument, it suggests that a POSITA would combine the bitstream of Figure 5B with the decoding pathways of Figure 4. Pet. 41.

109. This is crucial, because Figure 4 provides the only source of potential evidence that Petitioner relies upon for the claimed "decoding from the video sequence an indication of at least one image frame". Kim's specification makes clear that the controller of Kim does consider IAD information until **after** it decodes the requested frame and that Kim's method (Kim Fig 4) does not consider IAD information **at all** if the requested image is an I-picture. Kim's Figure 2, identifies the components of Kim:



110. As explained in Kim column 5, the decoder first reproduces the correct, requested image data, a process of decoding (lines 11-25, also shown as steps S21, S22, and S23 in Figure 4). Only after that decoding process does the Kim decoder actually consider what “type” the original data is and thereafter detect the address of the corresponding I-picture. Fig. 4 (step S31/S32); 5:38-45.

111. Neither Kim’s Controller 150 or Decoder 111 determine the “type” of the original data. Instead, an entirely different component DSP 121, performs this step. Kim, 5:34-37 (“Then the property (type) of the currently restored image data is determined in Step S31 by the reproducing DSP 121, and the determination result is transmitted to the controller 150.”).

112. Thus Kim’s system does not consider or determine the type of a coded

image frame and detect the address of a corresponding I-picture (denoted by the IAD field associated with a P-picture) until after the coded image frame has been decoded. Further, at no point does Kim disclose detecting the address of a corresponding I-picture (the IAD field) **for an I-picture**. This is not surprising, as the IAD field can be “zero or absent” for an I-picture as I explained earlier. Thus, it is not possible for Kim to disclose this limitation as it does not actually decode from a video sequence an indication of a first image frame.

113. Therefore, it is my opinion that Petitioner has failed to show a reasonable likelihood of success with respect to Kim for this limitation of the claims.

b. Petitioner fails to demonstrate that limitations 8[b], 10[b], and 11[b] are obvious over Kim for the same reasons as 8[a], 10[a], and 11[a]

114. Each of limitations 8[b], 10[b], and 11[b] are written with similar language and require “indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence” as with 8[a], 10[a], and 11[a]. And, as discussed above in VIII.2.a, Kim does not teach or suggest the “indication of at least one image frame, which is the first image frame, in decoding order, of an independent sequence” as the claim requires.

115. Further, as I explained above, Kim discloses that the IAD field for an I-picture can be “zero or absent” and a POSITA reading the disclosure would

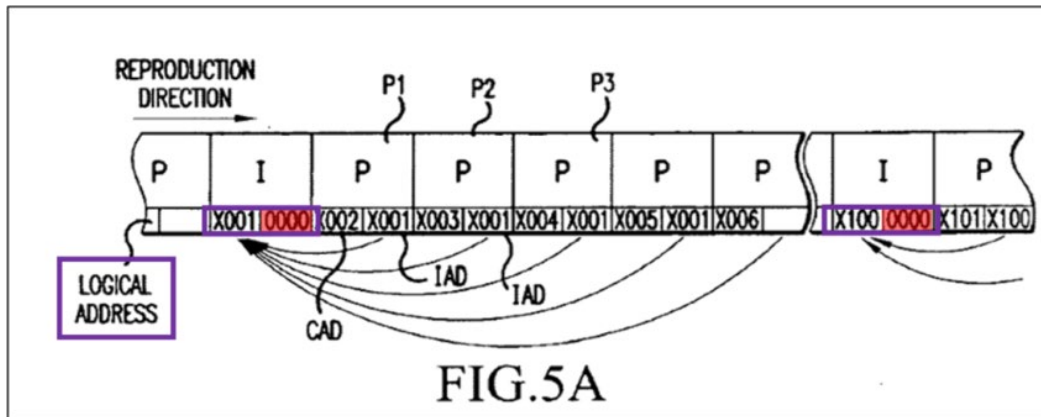
understand that this field could take any value or no value at all, as it is not used by Kim's reproducing method. Kim, 4:66-5:1. As the IAD field for an I-picture can be "zero or absent" in Kim, it does not have any functional use and therefore a POSITA would recognize that it is not "decoded from [a] video sequence."

116. Therefore, it is my opinion that Petitioner has failed to show a reasonable likelihood of success with respect to Kim for this limitation of the claims.

c. Petitioner fails to demonstrate that limitations 8[d], 10[d], and 11[d] are obvious over Kim because Kim does not teach or suggest resetting the identifier value as required

117. Each of limitations 8[d], 10[d], and 11[d] are written with similar language and require "[resetting/reset] the identifier value for the indicated first image frame of the independent sequence," and I therefore analyze them together here. In my opinion, Petitioner has failed to show that Kim teaches or suggests these limitations.

118. Contrary to Petitioner's argument, Kim does not teach resetting the identifier value. Petitioner argues, at Pet. 55, that Figure 5A "shows that the IAD component of each logical address is reset to zero for each I-picture" and provides an annotated Figure 5 (reproduced below) where the I-picture logical address is in red and the "whole logical address" is outlined in purple:



Pet. 56.

119. Petitioner asserts that Figure 4 is the alleged decoder, but nowhere in Figure 4 or anywhere else in Kim is there any disclosure that the decoder carries out any logical addressing, nor any resetting, of the IAD component.

120. In fact, the contrary appears true from Kim's limited disclosure, which states: "[i]n Step S13, the MUX 130 selectively outputs the I-picture data (or P-picture data), the camera ID code, and *the address of the I-picture data received from the encoder 110*, the recording DSP 120 and the controller 150, *and generates a bit stream of certain bytes for each frame.*" EX1006, 4:38-42, emphasis added.

121. Therefore, it is my opinion that Petitioner has failed to show a reasonable likelihood of success with respect to Kim for this limitation of the claims.

3. Petitioner Has Not Established A Reasonable Likelihood That The Challenged Claims Are Unpatentable In Light Of Ground 3.

a. Petitioner fails to demonstrate that Claim 9 is obvious over MPEG-1 in combination with Yagasaki

122. Petitioner cannot show it met its burden for Ground 3. Claim 9

depends on Claim 8 and Petitioner relies on its Ground 1 to show the predicate independent claim is taught or suggested. But, as shown above in VIII.1.a-c, MPEG-1 fails to teach or suggest at least limitation 8[a], 8[b], and 8[d].

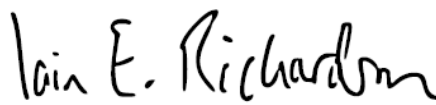
123. I understand that to show invalidity for a dependent claim, the Petitioner must also show invalidity for the independent claim from which it depends. Thus, because it is my opinion that Petition has not shown a reasonable likelihood of success in invalidating independent claim 8, it cannot show a reasonably likelihood of success for dependent claim 9.

IX. SIGNATURE

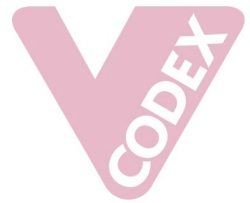
124. This Declaration represents the opinions that I have formed up to date based on the material currently available to me. I reserve the right to revise, supplement, and/or amend my opinions stated in this Declaration based on new information that becomes available to me and on my continuing analysis of the materials available to me.

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

Dated: June 27, 2024

A handwritten signature in black ink that reads "Iain E. Richardson". The signature is written in a cursive, slightly slanted style. Below the signature is a horizontal line.

Dr. Iain Richardson



Iain E. Richardson

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Internationally known expert on video compression, streaming technology and standards including H.264 / MPEG-4 and HEVC. Author of four widely cited books on video and image coding. Experienced expert witness in US and international patent litigation cases.

Personal Profile

Regularly advise companies on video compression and streaming technology, video coding patents and technology acquisitions. Expert witness in multiple US and EU patent litigation cases. I have given expert testimony in San Diego, New York, Washington DC and The Hague and have given many invited lectures on video compression coding, including the Smithsonian Institution and the US Patent and Trademark Office.

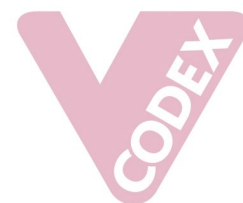
I have made an internationally significant contribution to research in the field of image and video compression. This is the essential technology for applications such as digital television, internet video streaming and video on mobile phones. My research addresses the growing challenge faced by industry, namely how to support sophisticated video compression on an increasing range of devices and platforms. Member of the expert group responsible for coding of audio, picture and multimedia content, within NEN, the Royal Netherlands Standardization Institute. Member of Advisory Group 5 (Video Quality) of ISO/IEC SC29, the committee responsible for the MPEG and JPEG video, audio and image compression standards.

I invented and commercialised Beamshare, a novel technology for rapid and secure sharing and streaming of video and other media. Beamshare is now in use in industries such as Search and Rescue and broadcast video production.

I am based in the Netherlands and travel frequently to the US.

Qualifications

Ph.D. (1999), Video Coding for Reliable Communications, Robert Gordon University, Aberdeen, UK
M.Eng. (1990), Electrical and Electronic Engineering, Heriot-Watt University, Edinburgh, UK



Employment experience

2006 - present	Managing Director, Vcodex Limited, Aberdeen, Scotland & Vcodex B.V., Delft, The Netherlands
2009 – 2015	Managing Director, Onecodec Ltd, Aberdeen, UK
1993 - 2010	Full Professor, School of Engineering, The Robert Gordon University
1995 - 2000	Director, 4i2i Communications Ltd
1990 - 1993	Digital Signal Processor Designer, GEC Ltd, Edinburgh

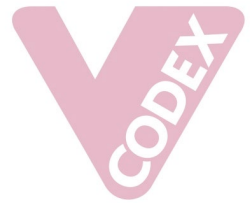
Professional affiliations

Honorary Professor of Video Communications, Robert Gordon University, Aberdeen, UK
Member, Advisory Group 5 (Video Quality), ISO/IEC SC29 (MPEG)
Member, Royal Netherlands Standardization Institute
Member, IEEE
IAM Strategy 300 (2017, 2018): The World's Leading IP Strategists

Expert witness and intellectual property experience

As an experienced expert witness in patent litigation cases, I have testified at deposition and trial in:

1. *Qualcomm Inc v. Broadcom Corporation SDCA-3-05-cv-01958*
United States District Court, Southern District of California), 2006
(Video Compression, H.264)
On behalf of *Qualcomm Inc*
2. *Electronic Devices With Image Processing Systems, Components Thereof, and Associated Software ITC-337-TA-724*
United States International Trade Commission Investigation, 2011
(Graphics compression)
On behalf of *S3 Graphics, Inc.*
3. *Multimedia Patent Trust v. Apple Inc., et. al. SDCA-3-10-cv-02618*
United States District Court, Southern District of California, 2012
(Video Compression, MPEG-2 and H.264)
On behalf of *Multimedia Patent Trust*
4. *Audiovisual Components ITC-337-TA-837*
United States International Trade Commission Investigation, 2013
(Data / Video compression, H.264)
On behalf of *LSI Corporation*
5. *Certain Video Processing Devices, Components Thereof, and Digital Smart Televisions Containing the Same; Inv. No. 337-TA-1222*
United States International Trade Commission Investigation, 2021
(Video Streaming)
On behalf of *DivX*
6. *Certain Fitness Devices, Streaming Components Thereof, and Systems Containing Same; 337-TA-1265*
United States International Trade Commission Investigation, 2022
(Video Technology)
On behalf of *Peloton Interactive, Inc., Mirror and Icon Health & Fitness, Inc*
7. *Certain Video Processing Devices and Components Thereof; Inv. No. 337-TA-1343*



United States International Trade Commission Investigation, 2023
(Video Streaming)
On behalf of *DivX*

I have testified at deposition in:

8. *Multimedia Patent Trust v. Directv, Inc. et al SDCA-3-09-cv-00278*
United States District Court, Southern District of California, 2011
(Video compression, MPEG-2 and H.264)
On behalf of *Multimedia Patent Trust*
9. *Portable Electronic Communications Devices, Including Mobile Phones and Components Thereof ITC-337-TA-885*
United States International Trade Commission Investigation, 2013
(Video Compression)
On behalf of *Google*
10. *International Business Machines Corporation v. Intellectual Ventures I LLC PTAB-IPR2015-00302*
Patent Trial and Appeal Board, Inter Partes Review, 2015
(Data and Video Compression)
On behalf of *Intellectual Ventures LLC*
11. *International Business Machines Corporation v. Intellectual Ventures I LLC PTAB-IPR2015-01089*
Patent Trial and Appeal Board, Inter Partes Review, 2016
(Data and Video Compression)
On behalf of *Intellectual Ventures LLC*
12. *Avago Technologies General IP (Singapore) Pte. Ltd. v. ASUSTeK Computer, Inc. et al NDCA-3-15-cv-04525*
United States District Court, Northern District of California, 2016
(Video Compression)
On behalf of *Avago Technologies*
13. *Broadcom Corporation et al v. Sony Corporation et al CDCA-8-16-cv-01052*
United States District Court, Central District of California, 2017
(Video Compression)
On behalf of *Broadcom Corporation et al.*
14. *Global Tel*Link Corporation v. Securus Technologies, Inc. PTAB-IPR2016-01362*
Patent Trial and Appeal Board, Inter Partes Review, 2017
(Video Communications)
On behalf of *Global Tel*Link Corporation*
15. *Sound View Innovations, LLC v. Hulu, LLC CDCA-2-17-cv-04146*
United States District Court, Central District of California, 2017
(Video Streaming)
On behalf of *Sound View Innovations, LLC*
16. *Semiconductor Devices and Consumer Audiovisual Products Containing the Same ITC-337-TA-1047*
United States International Trade Commission Investigation, 2017
(Video Compression)
On behalf of *Broadcom Corporation*
17. *Unified Patents Inc. v. Realtime Adaptive Streaming LLC PTAB-IPR2018-00883*
Patent Trial and Appeal Board, Inter Partes Review, 2019
(Data and Video Compression)

- On behalf of *Unified Patents Inc.*
18. *Realtime Adaptive Streaming LLC v. Google LLC et al CDCA-2-18-cv-03629*
United States District Court, Central District of California, 2019
(Video Compression)
On behalf of *Google LLC*
 19. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2019-00194*
Patent Trial and Appeal Board, Inter Partes Review, 2019
(Video Coding)
On behalf of *Velos Media, LLC*
 20. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2020-00707*
Patent Trial and Appeal Board, Inter Partes Review, 2020
(Video Coding)
On behalf of *Velos Media, LLC*
 21. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2020-00757*
Patent Trial and Appeal Board, Inter Partes Review, 2020
(Video Coding)
On behalf of *Velos Media, LLC*
 22. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2020-00710*
Patent Trial and Appeal Board, Inter Partes Review, 2020
(Video Coding)
On behalf of *Velos Media, LLC*
 23. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2020-00635*
Patent Trial and Appeal Board, Inter Partes Review, 2020
(Video Coding)
On behalf of *Velos Media, LLC*
 24. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2020-00763*
Patent Trial and Appeal Board, Inter Partes Review, 2020
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On behalf of *Velos Media, LLC*
 25. *Unified Patents Inc. v. Velos Media, LLC PTAB-IPR2020-00352*
Patent Trial and Appeal Board, Inter Partes Review, 2020
(Video Coding)
On behalf of *Velos Media, LLC*
 26. *Certain Mobile Electronic Devices and Laptop Computers; 337-TA-1215*
United States International Trade Commission Investigation, 2021
(Image Technology)
On behalf of *Maxell, Ltd.*
 27. *Broadcom Corporation et al v. Netflix, Inc. NDCA-3-20-cv-04677*
United States District Court (Northern District of California), 2022
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On behalf of *Broadcom Corporation et al.*
 28. *Maxell, Ltd. v. Lenovo Group Ltd. et al WDTX-6-21-cv-01169*
United States District Court (Western District of Texas), 2022
(Image Technology)
On behalf of *Maxell, Ltd.*
 29. *Video Processing Devices and Products Containing the Same; 337-TA-1323*
United States International Trade Commission Investigation, 2023
(Video Coding)
On behalf of *VideoLabs, Inc.*
 30. *Certain Mobile Electronic Devices; 337-TA-1324*
United States International Trade Commission Investigation, 2023

- (Image Technology)
On behalf of *Maxell, Ltd.*
31. *Broadcom Corporation et al v. Netflix, Inc. NDCA-3-20-cv-04677*
United States District Court (Northern District of California), 2023
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On behalf of *Broadcom Corporation et al.*
 32. *VideoLabs, Inc. v. Dell Technologies Inc. et al WDTX-6-21-cv-00456*
United States District Court (Western District of Texas), 2023
(Video Coding)
On behalf of *VideoLabs, Inc.*
 33. *Electronic Devices Including Smartphones, Computers, Tablet Computers, and Components Thereof.; 337-TA-1373*
United States International Trade Commission Investigation, 2024
(Video Technology)
On behalf of *InterDigital, Inc.*

Publications and invited lectures

Books/Chapters/Theses

1. Iain Richardson, *Coding Video*, John Wiley and Sons, due August 2024.
2. Iain Richardson, *H.264 Advanced Video Compression*, John Wiley and Sons, May 2010.
3. Iain Richardson, *H.264 and MPEG-4 Video Compression*, John Wiley and Sons, 2003.
4. Iain Richardson, *Video Codec Design*, John Wiley & Sons, 2002.
5. Iain Richardson, "Coefficient Modelling in a Block-Based Video CODEC", in *IMAGE PROCESSING III: Mathematical Methods, Algorithms and Applications*, Horwood Publishing, ISBN 1-898563-72-1, 2001.
6. Iain Richardson, "Video Coding for Reliable Communications", PhD Thesis, The Robert Gordon University, October 1999.
7. Mohammed Ghanbari and Iain Richardson (editors), *Proceedings of International Workshop on Audio-Visual Services over Packet Networks*, 1997.
8. M J Riley and Iain Richardson, *Digital Video Communications*, Artech House, 1997.

Standards contributions

1. Y. Zhao, M. Bystrom, C.S. Kannangara, I. Richardson and J. Philp, "A Random Access Protocol for Configurable Video Coding", Document M16927, ISO/IEC JTC1/SC29/WG11 (MPEG), China, October 2009.
2. I.E. Richardson, C.S. Kannangara, M. Bystrom, J. Philp and Y. Zhao, "Fully Configurable Video Coding, Part 2 - A Proposed Platform for Reconfigurable Video Coding", Document M16752, ISO/IEC JTC1/SC29/WG11 (MPEG), London, July 2009.
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1. I. Richardson, "Compressed Video Quality", *IASA Journal No. 48*, February 2018
2. I. Richardson, "Video compression codecs: a survival guide", *IASA Journal No. 47*, January 2017.
3. A. Bhat, C. S. Kannangara, Y. Zhao and I. Richardson, "A Full Reference Quality Metric for Compressed Video Based on Mean Squared Error and Video Content", *IEEE Trans. Circuits and Systems for Video Technology*, Vol 22:2, February 2012.
4. A. Bhat, I. Richardson and C. S. Kannangara, "A new perceptual quality metric for compressed video based on mean squared error", *Signal Processing: Image Communication*, Vol 25, 2010, pp. 588 - 596
5. M Bystrom, I Richardson, S Kannangara and M de Frutos-Lopez, "Dynamic Replacement of Video Coding Elements", *Signal Processing: Image Communication*, Vol 25:4, April 2010.
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7. C S Kannangara, I E Richardson & A J Miller, "Computational Complexity Management of a Real-Time H.264/AVC Encoder", *IEEE Trans. Circuits and Systems for Video Technology*, September 2008.
8. M. Bystrom, I. Richardson and Y. Zhao, "Efficient Mode Selection for H.264 Complexity Reduction in a Bayesian Framework," *Signal Processing: Image Communication*, vol. 23, iss. 2, pp. 71-86, February 2008.
9. C S Kannangara, I E G Richardson, M Bystrom, J Solera, Y Zhao, A MacLennan & R Cooney, "Low Complexity Skip Prediction for H.264 through Lagrangian Cost Estimation", *IEEE Transactions on Circuits and Systems for Video Technology*, February 2006.
10. L Muir and I E G Richardson, "Perception of Sign Language and its Application to Visual Communications for Deaf People", *Journal of Deaf Studies and Deaf Education*, September 2005.
11. I E G Richardson and S Kannangara, "Fast subjective video quality measurement with user feedback", *Electronics Letters*, Vol. 40, Number 13, June 2004 pp. 799-800.
12. Y Zhao and I E G Richardson, "Macroblock Classification for Complexity Management of Video Encoders", *Signal Processing: Image Communication*, Vol. 18, Issue 9, Oct. 2003 pp. 801-811.
13. I E G Richardson and Y Zhao, "Adaptive Management of Video Encoder Complexity", *Journal of Real-Time Imaging*, Vol. 8, No. 4, Aug 2002, pp. 291-301.
14. I E G Richardson, M J Riley, W Haston and I Armstrong, "Telemedicine and teleconferencing: the SAVIOUR project", *IEE Computing and Control Journal*, January 1996.
15. I E G Richardson and M J Riley, "Improving the error tolerance of MPEG video by varying slice size", *Signal Processing Journal*, Vol. 46, No. 3, October 1995.

Invited lectures

Invited lectures include:

1. "Adaptive Bitrate Streaming", *United States Patent and Trademark Office TC2400 Tech Fair*, 2022
2. "Motion Vector Prediction in Video Coding", *United States Patent and Trademark Office TC2400 Tech Fair*, 2021
3. "A brief history of video coding", *United States Patent and Trademark Office TC2400 Tech Fair*, 2014
4. "Coding video", *Smithsonian Institute / Library of Congress*, Washington DC, 2013
5. "Configurable video coding", *Rochester Institute of Technology*, Rochester, NY, 2009
6. "Dynamic configuration: beyond video coding standards", plenary presentation, *IEEE International System on Chip Conference (SOCC08)*, 2008

Papers in refereed conference proceedings

1. A. Bhat, I. E. Richardson & C. S. Kannangara, "A Novel Perceptual Quality Metric for Video Compression", *Proc. International Picture Coding Symposium 2009*, Chicago, May 2009.
2. I. Richardson, C. S. Kannangara, M. Bystrom, J. Philp and M. De. Frutos-Lopez, "A Framework for Fully Configurable Video Coding," *Proc. International Picture Coding Symposium 2009*, Chicago, May 2009.
3. A. Bhat, I. Richardson and S. Kannangara, "A New Perceptual Quality Metric for Compressed Video", *Proc. ICASSP 2009*, Taipei, Taiwan, April 2009.
4. C. S. Kannangara, I. Richardson, M. Bystrom, M. de-Frutos-Lopez, "Fast, Dynamic Configuration of Transforms for Video Coding", *Proc. ICIP 2008*, San Diego, California, October 2008.
5. I E Richardson, "Dynamic Configuration: Beyond Video Coding Standards", *Invited Plenary Presentation, IEEE System on Chip Conference (SOCC08)*, Newport Beach, CA, September 2008.
6. I. Richardson, M. Bystrom, M. de-Frutos-Lopez, C. S. Kannangara, "Dynamic Transform Replacement in an H.264 Codec", *Proc. ICIP 2008*, San Diego, California, October 2008.
7. Chaminda Kannangara, Yafan Zhao, Iain Richardson and Maja Bystrom, "Complexity Control of H.264 Based on a Bayesian Framework", *Proc. PCS 2007*, Portugal, November 2007.
8. Y Zhao, M Bystrom and I E Richardson, " A MAP Framework for Efficient SKIP/CODE Mode Decision in H.264", *Proceedings of International Conference on Image Processing*, Atlanta, USA, 8-11 October 2006.
9. C S Kannangara, I E Richardson and A Miller, "Computational Management of an H.264 Encoder," *Proceedings of International Picture Coding Symposium*, Beijing, China, 24~26 April 2006.
10. I E Richardson, M Bystrom and Y Zhao, "Fast H.264 Skip Mode Selection Using an Estimation Framework", *Proceedings of International Picture Coding Symposium*, Beijing, China, 24-26 April, 2006.

11. C. S. Kannangara and I. E. Richardson, "Computational Control of an H.264 Encoder Through Lagrangian Cost Function Estimation", International Workshop on Very Low Bitrate Video, Sardinia, Italy, 15-16 September 2005.
12. L J Muir, I E G Richardson and K Hamilton, "Visual perception of Content-Prioritised Sign Language Video Quality". Proceedings IEE Visual Information Engineering, Glasgow. 4 ~ 6 April 2005.
13. Y Zhong, I Richardson, A Miller and Y Zhao, " Perceptual Quality Of H.264/AVC Deblocking Filter", Proceedings IEE Visual Information Engineering, Glasgow, 4~6 April, 2005.
14. C S Kannangara, I E G Richardson, M Bystrom, J Solera, Y Zhao, A MacLennan & R Cooney, "Complexity Reduction of H.264 using Lagrange Optimization Methods," Proceedings IEE Visual Information Engineering, Glasgow, 4~6 April, 2005.
15. I E G Richardson and Y Zhao, "Video Encoder Complexity Reduction by Estimation Skip Mode Distortion", Proc. ICIP 2004, Singapore, Oct. 2004.
16. Y Zhong, I Richardson, A Sahraie and P McGeorge, "Influence of Task and Scene Content on Subjective Video Quality", Lecture Notes in Computer Science, Volume 3211 / 2004, pp. 295.
17. W W Lee, I E G Richardson and R Staff, "Volumetric Analysis of Brain MRI scans Using Geometric Deformable models. ", ESMRMB 2004, September 2004, Copenhagen.
18. C S Kannangara, I E G Richardson and Y Zhao, "H.264 Complexity Management using Macroblock Skip-Mode Prediction", PGNet, Liverpool, June 2004.
19. Y Zhong, I Richardson, A Sahraie and P McGeorge, "Qualitative and quantitative assessment in video compression", 12th European Conference on Eye Movements, 20-24 August 2003, Dundee, Scotland.
20. Yafan Zhao and Iain Richardson, "Macroblock skip-mode prEdiction for Complexity control of Video Encoders", IEEE Visual Information Engineering, Surrey, July 2003.
21. Laura Muir, Iain Richardson, Steven Leaper, "Gaze tracking and its application to video coding for sign language", International Picture Coding Symposium 2003, Saint Malo - France, 23~25, April 2003.
22. Yafan Zhao, Iain Richardson, "Macroblock classification for video encoder complexity management", International Picture Coding Symposium 2003, Saint Malo - France, 23~25, April 2003.
23. Y Zhao and I E G Richardson, "Complexity Management for Video Encoders", Doctoral Symposium, ACM Multimedia Conference, Juan Les Pins, France, 1-6 December 2002.
24. L Muir and I E G Richardson, "Video Telephony for the Deaf: Analysis and Development of an Optimised Video Compression Product", Doctoral Symposium, ACM Multimedia Conference, Juan Les Pins, France, 1-6 December 2002.
25. Y Zhao, L Muir and I E G Richardson, "Implementing MPEG-4 Visual in software", IEE Seminar on Visual Media Standards, 25 April 2002
26. Y Zhao and I E G Richardson, "Computational Complexity Management of Motion Estimation in Video Encoders", IEEE Data Compression Conference (DCC02), Snowbird, Utah, April 2002.
27. I E G Richardson and Y Zhao, "Adaptive Algorithms for Variable Complexity Video Coding", Proc. International Conference on Image Processing (ICIP01), Thessaloniki, Greece, October 2001.

28. I E G Richardson and Y Zhao, "Video CODEC Complexity Management", Proc. International Picture Coding Symposium (PCS01), Seoul, Korea, April 2001.
29. I E G Richardson, K Kipperman et al, "Video Coding using Digital Signal Processors", DSP World Fall Design Conference, Orlando, USA, November 1999 (invited workshop).
30. M J Riley, I E G Richardson, K Kipperman, L Muir and G Smith, "High speed bit accurate communication system modelling in C", Proc. DSP World Spring Design Conference, Santa Clara, USA, April 1999.
31. I E G Richardson, A J Turnbull and M J Riley, "Temporal Filtering of Coded Video", Proc. SPIE Int. Conf. on Digital Compression Technologies and Systems for Video Communications, Berlin, October 1996.
32. M J Riley and I E G Richardson, "Quality of Service Issues for MPEG-2 Video over ATM", Proc. IEE International Broadcasting Convention, Amsterdam, September 1996.
33. M J Riley and I E G Richardson, "An Optimised Implementation of Reed-Solomon FEC on the PC", Proc. 4th UK/Australian International Symposium on DSP for Communication Systems, Perth, September 1996, published as chapter in "Digital Signal Processing for Communication Systems", Kluwer Academic Publishers.
34. M J Riley and I E G Richardson, "An FEC Protocol for Video over ATM", Proc. Fourth Workshop on Performance Modelling and Evaluation of ATM Networks, Ilkley, W.Yorkshire, July 1996.
35. I E G Richardson and M J Riley, "Controlling the rate of MPEG video by dynamic variation of sequence structure", Picture Coding Symposium, Melbourne, March 1996.
36. I E G Richardson, I J Hunter and M J Riley, "Temporal smoothing of coded video data", Picture Coding Symposium, Melbourne, March 1996.
37. I E G Richardson and M J Riley, "Reducing cell loss effects on MPEG video by varying slice size", International Packet Video Workshop, Brisbane, March 1996.
38. I E G Richardson and M J Riley, "Varying slice size to improve error tolerance of MPEG video", Proc. SPIE vol. 2668, Digital Video Compression 96, San Jose, January 1996.
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40. I E G Richardson and M J Riley, "Video Quality of Service in Broadband Networks", Proc. IEE International Broadcasting Convention 95, Amsterdam, September 1995.
41. M J Riley and I E G Richardson, "Minimising the Effect of Cell Losses on MPEG Video", Proc. 4th Int. Conference on Broadband Islands, Dublin, September 1995.
42. I E G Richardson and M J Riley, "MPEG Coding for Error-Resilient Transmission", Proc. IEE Image Processing and its Applications 95, Edinburgh, July 1995.
43. M J Riley, B U Kohler and I E G Richardson, "A Variable Block Length FEC Protocol for MPEG Packet Video", Proc. 3rd Int. Symposium on Communication Theory and Applications, Ambleside, July 1995.
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Patents / Patent Applications Include

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