**ISO/IEC JTC1/SC29/WG1 N505**
**21 March 1997**

**ISO/IEC JTC1/SC29/WG1**
**(ITU-T SG8)**

# Coding of Still Pictures

**JBIG**
Joint Bi-level Image Experts Group

**JPEG**
Joint Photographic Experts Group

**TITLE:** Call for contributions for JPEG 2000 (JTC 1.29.14, 15444): Image Coding System

**SOURCE:** ISO/IEC JTC1/SC29/WG1

**PROJECT:** JTC 1.29.14 (15444)

**STATUS:** Approved call for contributions

**REQUESTED ACTION:** Technology contributions

**DISTRIBUTION:** WG1 Mailing List, SC29 committee, unlimited distribution

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# Call for contributions for JPEG 2000 (JTC 1.29.14, 15444): Image Coding System

## Executive summary

This call for contributions describes the contribution, testing, and technology merging that will progress toward development of a new standard for the compression of still imagery. Two types of contributions are sought: compression architectural frameworks and compression algorithms. The International Standards Organization (ISO) New Work Item (NWI) describing this project is found in Annex A.

This call for Joint Photographic Experts Group (JPEG) 2000 image coding system contains:

- Executive summary: Overviewing of the contribution process.
- Body: Detailing the contribution and testing process
- Annex A: New Work item: JPEG 2000 image coding system (N390R).
- Annex B: National points of contact for participation

### Participation

This document describes the process through which companies and/or individuals may contribute to the development of JPEG 2000. Additionally, it is expected that contributors would regularly participate in the activities of the committee. This requires accreditation by the contributors respective national standards body. Please contact your national committee (Annex B) or Dr. Daniel Lee, SC29/Wg1 Convener, for information. Additionally, it is important to note that it is not expected that a contributor provide a complete solution to the JPEG 2000 problem. In fact, it is expected that the final standard will be a combination of technologies from a variety of sources.

### Process

The development cycle for JPEG 2000 will consist of several parts. The first of these will be the contribution of architectural frameworks for compression algorithms. This will be closely followed by the contribution of compression algorithms. The next stage will consist of the convergence of all submitted algorithms and architectural frameworks into a single standard. All algorithms will be verified during this stage. Finally, a standards document describing this single algorithm will be developed.

### Contribution Schedule

This contribution schedule is an extraction from the full schedule found in Section 1.

| | |
|---|---|
| Declaration of intent to contribute | As soon as possible |
| Submission of architectural frameworks | before 30 June 1997 |
| Presentation of architectural frameworks | 7-11 July 97, Sapporo, Japan |
| Submission of algorithms | before 30 September 1997 |
| Presentation of algorithms | 10-14 November 1997, Sydney, Australia |

## Contacts

Anyone who thinks their group might submit a contribution or has questions about the process should contact Dr. Daniel Lee and Mr. Bernard Brower.

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The submission package and test images are available on CD-ROM from Mr. Bernard Brower after 7 Apr 97. The submission packages described later in this document should be sent to Mr. Brower.

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# Call for contributions for JPEG 2000 (JTC 1.29.14, 15444)

# Image Coding System

## 1. Introduction

This call for contributions initiates a competitive process that will progress toward development of a new standard for the compression of still imagery. The scope of the JPEG 2000 development includes potential new compression algorithms and/or flexible compression architectures, processes and/or formats.

This document describes the contribution, testing, and technology merging that will be performed as part of the JPEG 2000 development effort. Potential submitters of technology should refer to the JPEG 2000 New Work Item for the definitive description of the standardization effort (Annex A, N390R).

It is important to note that the development committee is seeking contributions towards the development of JPEG 2000 in two highly related areas: compression architectural frameworks and compression algorithms. For proper time allocation, a separate contribution meeting is dedicated to each of these, followed by a technology convergence period that merges contributions from both into a single standard.

The goal of the contribution process is to gather algorithms, components of algorithms, and architectural frameworks; and to organize algorithm components into a single architecturally based standard. An architecturally based standard has the potential of allowing the JPEG 2000 standard to evolve and integrate new algorithm components without requireing a new standards definition.

Since the JPEG 2000 development effort is targeted at a wide range of compression applications, testing and merging will focus across application areas. Some examples of the application areas for JPEG 2000 include:

Table 1-1: Application Areas for JPEG 2000

| | |
|---|---|
| Document imaging | Financial documents |
| Facsimile | Security Cameras |
| Internet/WWW imagery | Client-Server |
| Laser print rendering | Scanner/digital copiers |
| Video component frames | Prepress |
| Photo and art digital libraries | Electronic Photography |
| Remote sensing | Elevation |
| Medical imagery | Seismic |

In general, the standardization process could produce several potential outcomes:

- Technology from a single contribution could satisfy all JPEG 2000 requirements
- Technologies from multiple contributions could be merged into a single algorithm or set of algorithms to meet all JPEG 2000 requirements
- Technologies from multiple contributions could be integrated into an architecturally based solution

## 1.1 Participation

In addition to the submission and presentation of the technology contributions, contributors are expected to participate in the full development cycle of the JPEG 2000 standard. This includes attendance in both international and appropriate national meetings as accredited national delegates and the performance of committee work both during and between the meetings.

Accreditation for participation in any ISO committee requires that you be nominated as a delegate by your respective national standards body. Each country maintains its own rules for becoming a delegate. Most have a specific national committee where participation qualifies the individual as a delegate. Please contact your national committee (Annex B) or Dr. Daniel Lee for information.

An important component of committee participation is the understanding of the work of other contributors and the participation in the convergence toward a standard that takes advantage of the best of all the contributions. This includes assisting in the design and execution of experiments to evaluate the mixing and matching of technology. Later, efforts will include participation in the design and execution of compliance tests and the writing, editing, and reviewing the standard document.

It is important to stress that it is not a requirement that an individual contribution satisfy all the goals of the JPEG 2000 effort. The convergence stage of this effort will merge technology presented in the contribution stage. In that environment partial contributions will be candidates for consideration as they improve the overall merging process. Thus, all contributors and participants are expected to understand all algorithm and architectural framework contributions.

## 1.2 Schedule

This Section contains a detailed schedule for JPEG 2000 development. This schedule is subject to modification by SC29/WG1 during development. The development cycle may be viewed as consisting of several parts. The first of these will be the contribution of concepts for architectural frameworks for compression algorithms. This will be closely followed by the contribution of compression algorithms. The next stage will consist of the convergence of all submitted algorithms and architectures into a single standard for compression. Development of the actual text of the standard will follow as a several step process. This text development consists of the creation of a Working Draft (WD), Committee Draft (CD), Draft International Standard (DIS), and the final International Standard (IS). The schedule of events, meetings, and deadlines are as follows:

- Contact Dr. Daniel Lee of the intent to contribute ASAP

- Submission of architecture contributions 30 Jun 97
- Architecture contributions accepted 7-11 July 1997, Sapporo, Japan

- Submission of algorithm contributions 30 Sep 97
- Submission of architecture contributions 31 Oct 97
- Algorithms contributions accepted 10-14 Nov 97, Sydney, Australia
- Architecture contributions accepted 10-14 Nov 97, Sydney, Australia

- Informal meetings between contributors Nov-Mar 98

- Second experimental results and convergence Mar 98, WG1 meeting

- JPEG 2000 Working Draft (WD) editing Mar-July 98
- Finalize working draft (WD) of the standard Jul 98, WG1 meeting
- WD to Committee Draft (CD) Jul 98, JPEG 2K editing mtg

- Opening of letter ballot for CD by SC29 Aug 98, SC29 meeting
- Closing of letter ballot for CD by SC29 Dec 98
- Dispensation of Comments Report (DOCR) for CD Mar 99, WG1 meeting
- CD to final CD Mar 99, WG1 meeting

- Opening of letter ballot for final CD Mar 99
- Closing of letter ballot for CD by SC29 Jul 99
- DOCR for final CD Nov 99, WG1 meeting
- Submit CD for Draft International Standard (DIS) Nov 99, WG1 meeting

- Opening of letter ballot for DIS Nov 99
- Closing of letter ballot for DIS Jan 00
- DIS submitted for International Standard (IS) Mar 00, WG1 meeting

- IS Nov 00

### 1.3 Intellectual property statement

Intellectual property rights are a major concern in this activity. The ISO requires that any contributor offers a license of the relevant intellectual property to all without favor for reasonable rates. Contributors should evaluate what their license compensation needs are before contributing to this standard.

## 1.4 References


- *New Work Item Proposal: JPEG 2000 image coding system,* ISO/IEC JTC1/SC29/WG1 document N390, 28 June 1996.
- *Proposed JPEG 2000 Evaluation Criteria and Approach.* ISO/IEC JTC1/SC29/WG1 N425, 11 November 1996.
- *Proposed JPEG 2000 Phase I Algorithm Test Package.* ISO/IEC JTC1/SC29/WG1 N424, 11 November 1996.
- *JPEG 2000 Algorithm Test and Submission Package.* ISO/IEC JTC1/SC29/WG1 N461, 15 November 1996.
- *New Work Item: JPEG 2000 image coding system,* ISO/IEC JTC1/SC29/WG1 document N390R, 21 March 1997.

# 2. Contribution and Convergence Process

Candidate JPEG 2000 compression concepts (architectural framework and algorithms) will be evaluated and merged into the final JPEG 2000 standard using the two-phase approach introduced above: Contribution and Convergence. This document focuses on Contribution Phase requirements.

The JPEG 2000 *Architectural Contribution Phase* consists of the submission of a written description of architectural frameworks and open architectures for compression by 30 June, 1997 or 31 October, 1997 with presentations at the the respective meeting following the contribution in July, 1997 or November, 1997.

The JPEG 2000 *Algorithm Contribution Phase* testing is to be executed by the technology submitters/developers as part of the technology submission process. The Contribution Phase concludes during October/November 1997, with contributions due 30 September and technical presentations during the November SC29/WG1 meeting

The *Convergence Phase* begins in November 1997 and ends with technology convergence in March 1998. During this phase, the operation of all algorithms will be verified, subjective evaluations of the quality of compression will be performed, and experts will collaborate informally in an effort to speed the convergence process. Aspects of the Convergence Phase testing and technology merging process are outlined in future documents.

It is expected that those both distince compression and architecture technology will contribute to both the algorithm and archecture contribution phases.

## 2.1 Contribution Phase architectural framework submission ( June 1997 or October 1997)

All architectural framework contributors will contribute their technology before June 30, 1997 or by October 31, 1997. The conclusion of the contribution will be a formal presentation at the respective SC29/WG1 meeting: July 1997 or November 1997.

These contributions include concepts that do not necessarily specify a particular algorithm, but instead specify an implementation, format, or methodology which may contain multiple algorithms and/or definitions and management functions. These contributions should include sufficient technical descriptions that algorithm technology contributors may make use of the framework concept submitted.

## 2.2 Contribution Phase technology submission ( September 1997)

All algorithm contributors will contribute their technology by 30 September, 1997. The conclusion of the contribution will be a formal presentation at the November 1997 SC29/WG1 meeting.

Contribution Phase testing is driven by an objective, self-certifying questionnaire to be executed by the technology contributors as part of the technology submission process. Section 3 describes this process in more detail, while Section 4 is a formal list of questions to be answered for each submission as part of the Contribution Phase. All test questions and submission requirements are derived from the JPEG 2000 New Work Item (Annex A, N390R).

It is important to note that algorithms will be initially evaluated and categorized based upon submissions made by their developers. Subjective tests will follow this initial evaluation. Of course, the nature of the convergence process will require submission of components of compression technologies (potentially from those already submitted during the Contribution Phase).

Finally, there are two other aspects of the Contribution Phase testing and technology submission that should be noted. First, executable code must be submitted to SC29/WG1. This executable code will be available for distribution to groups/organizations/individuals approved by SC29/WG1 to perform independent verification and testing of algorithms. Second, technology contributors will need to provide technical presentations describing the algorithms and briefs to ISO SC29/WG1 at the November SC29/WG1 meetings. Alternatively, contribution presentations may be made by proxy through the contributors respective National Body, with the National Body providing the reports and briefings. In extreme cases, presentations may be made by video (Note that the TV standard in Sydney is PAL).

## 2.3 Convergence Phase testing and merging (November 1997-March 1998)

The Convergence Phase testing and technology merging is an in-depth evaluation (objective and subjective) test and technology merging period to be performed on the best algorithms obtained during the Contribution Phase evaluation period. The purpose of the Convergence Phase is to combine the best compression technologies to yield the best compression algorithm possible; JPEG 2000 is not a winner-take-all competition. Submitters are strongly discouraged from attempting to introduce new compression technologies as part of the technology Convergence Phase. However, supplementary technology may be accepted.

A key part of Convergence Phase will be the merging of technologies. This will require the active participation of technology contributors in both technology discussions between meetings and at meetings. It is expected that during this period, Contribution Phase submitters will blend portions of their algorithms with other submitters as part of the merging process. It is expected that a large part of this process will take place through informal technology discussions among participants between meetings. Another key part of Convergence Phase will be subjective and objective testing. The subjective testing may include single-source evaluations of all algorithms submitted in Contribution Phase, visual evaluations, and other tests. Testing other than that specified in this document as part of Contribution Phase may also be included.

# 3. Contribution Instructions

This Section contains information for the submission of architectural frameworks and algorithms. Note that architectural frameworks are to be submitted in the June/July 1997 timeframe and algorithms are to be submitted in the October/November 1997 timeframe.

Where applicable:

bit rate = (file size of all data required for decompression*8)/(number of pixels).

## 3.1 Architectural Framework contribution instructions

Architectural framework contributors must submit written descriptions of their architectural framework and submit it to Dr. Lee by 30 June 1997. Additionally, submitters must present a briefing on their architectural frameworks at the July 1997 SC29/WG1 meeting. They may additionally submit algorithms as described below.

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## 3.2 Algorithm contribution instructions

ISO will provide the additional contribution information to algorithm contributors as part of a CD-ROM. This CD-ROM is available after 7 April 1997 from Mr. Brower. Mr. Brower will also collect all algorithm submissions by 30 September 1997.

Mr. Bernard Brower, Federal Systems Divisions
Eastman Kodak Company, 1447 St. Paul St., Rochester, NY 14653-7206, USA
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brower@kodak.com, e-mail

### 3.2.1 Information to be Provided by ISO

The CD-ROM available from Mr. Brower will contain the following information:

1) Contribution phase questionnaire in electronic form (Section 4 of this document). This document asks a number of questions designed to assist SC29/WG1 evaluate the submitted algorithms.

2) Test images that contributors are expected to compress, decompress, and submit to SC29/WG1 for evaluation. All but two images are luminance images. The remaining two are RGB color. While all contributors are expected to submit the luminance test images, only those contributors that have unique capabilities in the area of three-dimensional prediction (or similar techniques) are requested to submit color test images. Test images exhibit a variety of sizes and bit depths.

3) Sample error metric analysis code defining the error metrics that will be used to initially evaluate the images. These error metrics shall include the following: PEAK absolute Error, Mean Squared Error, Mean Absolute Error, 10%-90% Interval.

4) A read me file containing the final nature of various miscellaneous information including the following:

- A list of names of the image files, sizes, and bit depths
- A file naming convention for the submission of compressed images
- A file naming convention for the submission of decompressed images
- Valid media for submission (e.g., Zip drive/CD-ROM/exabyte tape)
- Valid file systems for submission (e.g., PC/MAC/UNIX/UNIX tar)
- Valid formats for submission(e.g., raw)
- Pixel structure of the test images(e.g., byte packed)
- Valid pixel structure for the submitted test images
- Bit rates for the testing of all images

### 3.2.2 Submission Package to be Provided by Contributors to ISO

Algorithms contributors must submit an algorithm submission package to Mr. Brower by 30 September 1997. Additionally, submitters must present a briefing on their algorithm at the November 1997 SC29/WG1 meeting.

A) The algorithm submission package consists of the following:

- Completed Contribution phase (Section 3) questionnaire
  - Hardcopy required
  - Softcopy desired in MS Word 6 for Windows or PDF
  - English
  - No handwritten submissions
- Compressed image files
  Filenames shall be uniform across submitters as described on the CD
  File Formats shall be uniform across submitters as described on the CD
- Corresponding reconstructed images from compressed image files.
  Filenames shall be uniform across submitters as described on the CD
  File Formats shall be uniform across submitters as described on the CD
- Executable code for the algorithm and usage instructions
  - Sparc/Solaris and/or Intel/NT and/or JAVA preferred
- Any other useful information you may wish to submit (such as a technical report)

B) The algorithm presentation during the November 1997 meeting is as follows:

- Introduces the central concepts of the algorithms
- Will consist of a presentation portion followed by questions
  - length provided by Dr. Lee by 15 October, 1997 based on the number of submissions and the time available at the meeting for presentations
- May be presented by proxy
- May in extreme cases be presented on video
- Shall additionally be provided in both hardcopy and softcopy for distribution

# 4. Questionnaire

This Section contains the questionnaire for completion by each contributor. Sections A-J contain questions of a general nature that will be used to characterize submitted algorithms. Section K contains questions that are directly derived from N390R, the approved JPEG 2000 Work Item.

## A. General Information

*1 Algorithm name*

*2 Technical point of contact*
name:
company:
address:
phone:
fax:
e-mail:

*3 Organizational point of contact*
name:
company:
address:
phone:
fax:
e-mail:

*4 Other participants*

*5 List and describe any additional material you are submitting.*

*6 Identify all stated or pending rights on all aspects of the algorithm.*

*7 If adopted, can technology be used license and royalty free?*

*8 Is the algorithm a candidate for any other national, international standards, or public specification?*

## B. Description of algorithm

*9 Provide a block diagram of the compression algorithm and brief descriptions of each component.*

*10 What transforms or decorrelators, if any, are used? Are they exactly invertible? Please describe.*

*11 What quantization is used? What rate or distortion allocation strategy is used? Please describe.*

*12 What entropy encoders, if any, are used? Please describe.*

*13 How are compressed data decompressed? Is the process symmetric in encoding and decoding complexity ? Is the process hierarchical in resolution? Is it progressive with respect to fidelity?*

*14 How were the submitted images generated (progressive resolution, progressive fidelity, other)? Please explain.*

*15 Does the algorithm (not the user) require training (e.g., neural networks)? If so, how complex is the training process? How much benefit does training provide? Is training practical on an individual image basis? Is training practical on an image class basis? Are there quantization tables to be used with the algorithm? Does the algorithm require or allow iteration?*

*16 Do you need to pad data prior to transform in some cases?*

*17 Please describe any capability you have to exploit multi-band correlation.*

## C. Implementation and Technical Constraints

*18 Are there any unique implementation requirements?*

*19 Is there a VLSI or DSP speedup available today? What speedup over software implementations are achieved? Please describe.*

*20 Are there any architectural or other requirements that might limit portability?*

## D. Quality

*21 How can losses introduced by the algorithm be characterized? Are these losses characteristic artifacts of the image? Are these losses characteristic of the compression algorithm? Characterize the growth of losses as a function of the compression rate (linear, exponential, step-like, etc.)*

*22 What is the error growth as a function of iterative compression /decompression at a given bit rate or paramater setting?*

*23 Characterize the losses in the color planes and their effect on the reconstructed image (if color coding is implemented)?*

## E. Complexity

*24 Please describe the complexity of your algorithm in detail.*

## F. Memory Requirements

*25 How many passes are needed to code the image (1 pass or more)?*

*26 How much of the image is minimally in RAM during compression? How much RAM is needed to hold this much of the image.*

*27 How much memory is required for algorithm operation.*

## G. Susceptibility to Channel Errors

*28 What are the consequences of a bit or byte error in the data stream? How does it depend on where the error occurs?*

*29 With a channel error in the compressed data what are the possibilities for image loss in the decompressed image?*

*30 What is the coding scheme (variable/fixed length coding)?*

*31 Is there coded data resynchronization implemented? If so, how often is it required?*

*32 Are any other methods of error recovery provided? If yes, please explain. (for example, error confinement or error concealment)*

*33 What percentage of the data is considered critical (as a function of the bit rate)?*

34 Are different levels *of data protection implemented? (for example, is the critical data handled differently?)*

## H. Rate Control

*35 Can the algorithm achieve a specific bit rate? If so, how is it achieved and at what complexity? (i.e., single pass, iteration)?*

*36 Can the algorithm be driven to a specific image quality metric? If so, what are the metrics, the range of control, and the complexity?*

*37 How precisely can a specified rate or quality be practically achieved?*

## I. File structure

*38 Describe briefly the bitstream syntax. Is there variable or fixed size (quantization, etc.) signaling?*

*39 Can your algorithm be adapted to independent tiling? Are there any border effects when doing so?*

*40 Can your data stream be adapted to be compliant with SPIFF format (10918-3 ANNEX F)? (yes, no, I don't know)*

*41 Please describe your header in content, structure, and byte count.*

## J. Features (derived directly from requirements stated in the Annex A, N390R, the JPEG 2000 NWI)

*The following table asks questions that are specifically related to the JPEG 2000 NWI. Please provide an expanded explanation of your answers as necessary.*

| | Question | Currently (yes/no/extent) | Potentially (yes/no/extent) |
|---|---|---|---|
| 1 | Are lossy and lossless compression naturally available during progressive decoding | | |
| 2 | Are both continuous-tone and bi-level compression available? | | |
| 3 | Can large images (>64k x 64k pixels) be compressed? | | |
| 4 | Is side channel spatial information (transparency/alpha) supported? | | |
| 5 | Are continuous-tone and bi-level compression available as a unified system? | | |
| 6 | Are lossless and lossy compression available in a single system? | | |
| 7 | Is fixed-rate compression available? | | |
| 8 | Is fixed-size compression available? | | |
| 9 | Can the image be compressed in a single pass? | | |
| 10 | Can the image be decompressed in a single pass? | | |
| 11 | Can the image be processed using component interleave order? | | |
| 12 | Can the image be processed using component non-interleave order? | | |
| 13 | How many scan lines are used in the sequential build-up capability (real time coding)? | | |

| | | | |
|---|---|---|---|
| 14 | Is progressive transmission by pixel precision available? | | |
| 15 | Is progressive transmission by spatial resolution available? | | |
| 16 | Is random codestream access and processing available via user-defined region of interest access? | | |
| 17 | Is random codestream access and processing available via tiling? | | |
| 18 | Is content-based description available? | | |
| 19 | Is JPEG backward compatibility supported?<br>Can you convert without additional losses? | | |
| 20 | Is this algorithm tailored for particular image types and applications? | | |
| 21 | Could this algorithm adopt an MSDL-like language? | | |
| 22 | Could this algorithm produce an object that can be considered as an MPEG-4 object? | | |
| 23 | Could a highly flexible coding tool be developed? | | |
| 24 | Does this algorithm allow the user to select appropriate tools? | | |
| 25 | Does this algorithm provide for future growth? | | |
| 26 | Does this algorithm allow dissemination of new compression tools? | | |
| 27 | Does this algorithm allow integration of new compression tools? | | |
| 28 | Does this algorithm provide a single decompression architecture? | | |
| 29 | Are watermarks/labeling/stamping (protective image security) provided or supported? | | |
| 30 | Is encryption (protective image security) provided or supported? | | |

# ANNEX A

# ISO/IEC SC29/WG1 N390R

**ISO/IEC JTC1/SC29/WG1**
**(ITU-T SG8)**

# Coding of Still Pictures

**JBIG**
Joint Bi-level Image Experts Group

**JPEG**
Joint Photographic Experts Group

**TITLE:** New work item: JPEG 2000 image coding system

**SOURCE:** ISO/IEC JTC1/SC29/WG1

**PROJECT:** JTC 1.29.14 (15444)

**STATUS:** Approved new work item

**REQUESTED ACTION:** None

**DISTRIBUTION:** WG1 Mailing List, SC29 committee

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## Title - New Work item: JPEG 2000 image coding system

## ISO/IEC JTC1/SC29/WG1, JTC 1.29.14 (15444)

## Purpose, scope, and goals for JPEG 2000

This new work item is intended to create a new image coding system that for different types of still images (bi-level, gray-level, color) with different characteristics (natural images, scientific, medical, remote sensing imagery, text, rendered graphics, etc.) allowing different imaging models (client/server, real-time transmission, image library archival, limited buffer and bandwidth resources, etc.) preferably within a unified system.

This coding system is intended to provide low bit-rate operation with rate-distortion and subjective image quality performance superior to existing standards, without sacrificing performance at other points in the rate-distortion spectrum. In addition, this system could include many modern features, listed in this document.

The standard will strive for openness and royalty-free licensing. It should be completed by the end of the millennium and offer state-of-the-art compression for at least ten years and beyond.

This standard will serve still image compression needs that are current not served by the current JPEG standards (IS 10918-1, IS 10918-2, IS 10918-3). (For example, very low bit-rate, progression for the WWW, medical imagery, pre-press, etc.) It is intended to compliment, not replace, the current JPEG standards. Indeed, this standard is expected to include an architectural context that will allow the previous standards to be used as desired on different tiles and/or components *within a single image*. This architecture will allow utilizing all of the current and future work of the JPEG committee to the best advantage.

## Purpose and justification

This standard is intended to advance standardized image coding systems to serve applications into the next millennium. It will provide a set of features vital to many high-end and emerging image applications by taking advantage of new modern technologies. Specifically, this new standard will address areas where current standards fail to produce the best quality or performance including the following. It will also provide capabilities to markets that currently do not use compression.

- **Low bit-rate compression performance**: Current standards, such as IS 10918-1 (JPEG), offer excellent rate-distortion performance in the mid and high bit-rates. However, at low bit-rates (e.g., below 0.25 bpp for highly detailed gray-level images) the distortion, especially when judged subjectively, becomes unacceptable.
- **Lossless and lossy compression**: There is no current standard that can provide superior lossless compression and lossy compression in a single codestream.
- **Large images:** Currently, the JPEG image compression algorithm does not allow for images greater then 64K by 64K without tiling.

- **Single decompression architecture:** The current JPEG standard has 44 modes, many of which are application specific and not used by the majority of the JPEG decoders. Greater interchange between applications can be achieved if a single common decompression architecture encompasses these features.

- **Transmission in noisy environments**: The current JPEG standard has provision for restart intervals, but image quality suffers dramatically when bit errors are encountered.

- **Computer generated imagery:** The current standard was optimized for natural imagery and does not perform well on computer generated imagery.

- **Compound documents:** Currently, JPEG is seldom used in the compression of compound documents because of its poor performance when applied to bi-level (text) imagery.

## Criteria for next generation compression

JPEG 2000 will be defined by its features. It will fill a gap in the rate-distortion spectrum (low bit-rate) of current still image compression standards and provide a set of features vital to many high-end and emerging image applications. Superior low bit-rate performance is primary. It is desirable to include as many of the other following features as possible.

- **Superior low bit-rate performance**: This standard should offer performance superior to the current standards at low bit-rates (e.g., below 0.25 bpp for highly detailed gray-scale images). This significantly improved low bit-rate performance should be achieved *without sacrificing performance on the rest of the rate-distortion spectrum.* Examples of applications that need this feature include network image transmission and remote sensing. This is the highest priority feature.

- **Continuous-tone and bi-level compression**: It is desired to have a standard coding system that is capable of compressing both continuous-tone and bi-level images. If feasible, this standard should strive to achieve this with similar system resources. The system should compress and decompress images with various dynamic ranges (e.g., 1 bit to 16 bit) for each color component. Examples of applications that can use this feature include compound documents with images and text, medical images with annotation overlays, and graphic and computer generated images with binary and near to binary regions, alpha and transparency planes, and facsimile.

- **Lossless and lossy compression**: It is desired to provide lossless compression naturally in the course of progressive decoding (difference image encoding, or any other technique, which allows for the lossless reconstruction is valid). Examples of applications that can use this feature include medical images where loss is not always tolerated, image archival applications where the highest quality is vital for preservation but not necessary for display, network applications that supply devices with different capabilities and resources, and pre-press imagery.

- **Progressive transmission by pixel accuracy and resolution**: Progressive transmission that allows images to be reconstructed with increasing pixel accuracy or spatial resolution is essential for many applications. This feature allows the reconstruction of images with different resolutions and pixel accuracy, as needed or desired, for different target devices. Examples of applications include the World Wide Web, image archival applications, printers, etc. The image architecture provides for the efficient delivery of image data in many applications such as client/server applications (World Wide Web).

- **Fixed-rate, fixed-size, limited workspace memory**: Fixed-rate (fixed local rate) means that the number of bits for a given number of consecutive pixels equals (or is less than) a certain value. This allows the decoder to run in real-time through channels with limited bandwidth. Examples are remote imaging, motion coding, etc. Fixed-size (fixed global rate) means that the total size of the codestream for a complete image equals a certain value. This allows hardware with a limited memory space to hold the complete codestream regardless of the image. Examples include scanners, printers, etc.

- **Random codestream access and processing**: Often there are parts of an image that are more important than others. This feature allows user defined regions-of-interest in the image to be randomly accessed and/or decompressed with less distortion than the rest of the image. Tiling of the image is a common and acceptable technical approach for this feature. Also, random codestream processing could allow operations such as rotation, translation, filtering, feature extraction, scaling, etc.

- **Robustness to bit-errors:** It is desirable to consider robustness to bit-errors while designing the codestream. One application where this is important is wireless communication channels. Portions of the codestream may be more important than others in determining decoded image quality. Proper design of the codestream can aid subsequent error correction systems in alleviating catastrophic decoding failures. Usage of error confinement, error concealment, restart capabilities, or source-channel coding schemes can help minimize the effects of bit-errors.

- **Open architecture:** It is desirable to allow open architecture to optimize the system for different image types and applications. This may be done either by the development of a highly flexible coding tool or adoption of a syntactic description language which should allow the dissemination and integration of new compression tools. Work being done in MPEG-4 on the development of a Syntactic Description Language (MSDL) may be of use. It is desired to allow the user to select tools appropriate to their application and provide for future growth. With this feature, the decoder is only required to implement the core tool set and a parser that understands the codestream. If necessary, unknown tools are requested by the decoder and sent from the source.

- **Sequential build-up capability (real time coding)**: The standard should be capable of compressing and decompressing images with a single sequential pass. This standard should also be capable of processing an image using component interleave order or non-interleaved order. During compression and decompression, the standard should use context limited to a reasonable number of lines. However, there is no requirement of optimal compression performance during sequential build-up operation.

- **Backwards compatibility with JPEG:** It is desirable to provide for backwards compatibility with the current JPEG standards.

- **Content-based description**: Finding an image in a large database of images is an important problem in image processing. For example, a doctor could request only images from a set that are recognized to have a certain type of tumor. This could have major applicability to the medical, law enforcement and environmental communities, and for image archival applications. There is reason to believe that a content-based description of images might be available as a part of the compression system. Regardless of the techniques used, JPEG 2000 should strive to provide the opportunity for solutions to this problem.

- **Protective image security**: Protection of a digital image can be achieved by means of one or more of four methods: watermarking, labeling, stamping, encryption. Watermarking is a mark set inside the image content to pass a protection message to the user. Labeling is already implemented in SPIFF and must be easy to transfer back and forth to JPEG 2000 image file. Stamping is a mark set on top of a displayed image that can only be removed by a specific process. Encryption can be applied on the whole image file or limited to part of it (header, directory, image data) to avoid unauthorized use of the image.

- **Interface with MPEG-4**: The ongoing standardization process for the "Coding of moving pictures and audio" (ISO/IEC JTC1/SC29/WG11), MPEG-4, is developing a syntax oriented coding scheme in which coding tools are chosen from a repertoire so as to address in an optimal way a wide range of functionalities. A syntactic description language provides a method for describing the coding representation to each object and the method used to code it. It is desirable that the coding tool (or tools) developed for the compression of still images in JPEG 2000 are provided with an appropriate interface allowing the interchange and the integration of such tools into the framework of a syntax oriented coding scheme such as MPEG-4.

- **Side channel spatial information (transparency)**: Side channel spatial information, such as alpha planes and transparency planes, are useful for transmitting information for processing the image for display, print, or editing, etc. An example of this is the transparency plane used in World Wide Web applications.

It is important to note that, while this standard addresses the needs of this wide variety of images and applications, it desirable that the decoder be able to interpret codestreams with minimal complexity. There must be a cost/benefit assessment of each function that adds complexity to the decoder.

## Markets and applications

JPEG 2000's desired capabilities should serve the following markets and applications where the current standards fail.

- **Low bandwidth dissemination of imagery**: Compression of images to low bit rates transmitted over low bandwidth transmission channels. Examples of applications include network image transmission, such as the World Wide Web, and archive and dissemination of remote sensing imagery where bandwidth is limited and expensive.

- **Medical imagery lossless/lossy compression:** Currently, the medical imagery community does not use lossy compression extensively because of the perceived and legal need for lossless compression. A lossless/lossy system could allow the use of lossy compression with the assurance that, if necessary, a lossless image is available.

- **Pre-press imagery:** Currently, the pre-press industry does not use JPEG because of the near lossless (visually lossless) and multiple resolution requirements which the current standard does not meet.

In addition to offering an acceptable compression standard for the above markets, JPEG 2000 could offer improved compression for the following markets and applications .

- **Client/server applications (World Wide Web):** The ability to post-process the compressed image file to extract only the data needed to reconstruct an image for a certain

target device is very useful. Also, there is a need for spatial side band information, such as a transparency plane.

- **Electronic photography:** The electronic photography market is expanding with more applications and new requirements. Lossless compression with the ability to make it lossy afterward could add considerable flexibility.
- **Photo and art digital libraries:** There is a significant increase in the use of photographic and art digital libraries which could be improved with progressive transmission by pixel accuracy or resolution.
- **Security:** The law enforcement and national security applications can be improved in the low bandwidth and noisy communication channels (i.e. wireless).
- **Facsimile**
- **Laser print rendering**
- **Scanner and digital copier memory buffers**

## Program of work

This document is the first step toward this standardization effort. It is desirable to move this standardization effort as quickly as possible. The following is the preliminary schedule for this new work item.

| | |
|---|---|
| • Contact Dr. Daniel Lee of the intent to contribute | ASAP |
| • Submission of architecture contributions | 30 Jun 97 |
| • Architecture contributions accepted | 7-11 Jul 197, Sapporo, Japan |
| • Submission of algorithm contributions | 30 Sep 97 |
| • Algorithms contributions accepted | 10-14 Nov 97, Sydney, Aust |
| • Second experimental results and convergence | Mar 98, Rochester, NY |
| • Finalize working draft (WD) of the standard | Jul 98, Europe |
| • WD to Committee Draft (CD) | Jul 98, Europe |
| • Opening of letter ballot for CD by SC29 | Aug 98, SC29 meeting |
| • Closing of letter ballot for CD by SC29 | Dec 98 |
| • Dispensation of Comments Report (DOCR) for CD | Mar 99, WG1 meeting |
| • CD to final CD | Mar 99, WG1 meeting |
| • Opening of letter ballot for final CD by ITTF | Mar 99, ITTF meeting |
| • Closing of letter ballot for CD by SC29 | Jul 99 |
| • DOCR for final CD | Nov 99, WG1 meeting |
| • Submit CD for Draft International Standard (DIS) | Nov 99, WG1 meeting |
| • Opening of letter ballot for DIS by ITTF | Nov 99, ITTF meeting |
| • Closing of letter ballot for DIS by ITTF | Jan 00 |
| • DIS submitted for International Standard (IS) | Mar 00, WG1 meeting |

This work is unlike the three other work items being pursued in the ISO/IEC JTC1/SC29/WG1 committee. The work item JTC 1.29.9 is an elegant complement to this

standard. JTC 1.29.9 is a multi-spectral compression standard that will provide a way to take advantage of the correlation in component planes of images such as LANDSAT or SPOT.

## Relevant documents

These documents demonstrate the feasibility of compression systems that have many of these desired features.

- AHG on MSDL issues, "Requirements for the MPEG-4 Syntactic Description Language (Revision 2)," *ISO-IEC/JTC1/SC29/WG11 N1022*, July 1995.
- A. Zandi, M. Boliek, E. Schwartz, A. Keith, "CREW Lossless/Lossy Image Compression," ISO/IEC JTC1/SC29/WG1 N196, 30 June 1995, and N252, 3 November 1995.
- A. Said, W. Pearlman, "A new, fast, and efficient image codec based on set partitioning in hierarchical trees," *IEEE Trans. on Circuits and Systems for Video Technology*, Vol. 6, No. 3, 3 June 1996.

## Cooperation and liaison

Because of the potential use with facsimile, networks, and satellite images, the joint status of the ISO/IEC JTC1/SC29/WG1 committee and the ITU-T SG8 committee is particularly useful.

The applicability to medical images suggests liaisons with the ACR-NEMA MED-PACS Working Group IV (US DICOM compression working group) and the MEDIS-DC (Japanese IS&C working group) and the European equivalent would be useful. Liaisons with groups within the defense establishments would also be important.

Liaison with ISO/IEC JTC1/SC29/WG11 MPEG-4 is suggested because of its work with the MSDL project. Liaison with ISO/IEC JTC1/SC24/WG7 is suggested because of its work on file formats.

## Preparatory work

The ISO/IEC JTC1/SC29/WG1 committee has members that are willing to do substantial work to test, prepare reference systems, and document this standard.

# ANNEX B

# NATIONAL POINTS OF CONTACT FOR PARTICIPATION

**National delegations**

Accreditation for participation in any ISO committee requires that you be nominated as a delegate by your respective national standards body. Each countries maintains its own rules for becoming a delegate. Most have a specific national committee where participation qualifies the individual as a delegate. Please contact your national committee or Dr. Daniel Lee for information.

**SC29/WG1 Convener:**

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