

# The Scan-Based Mode of JPEG 2000

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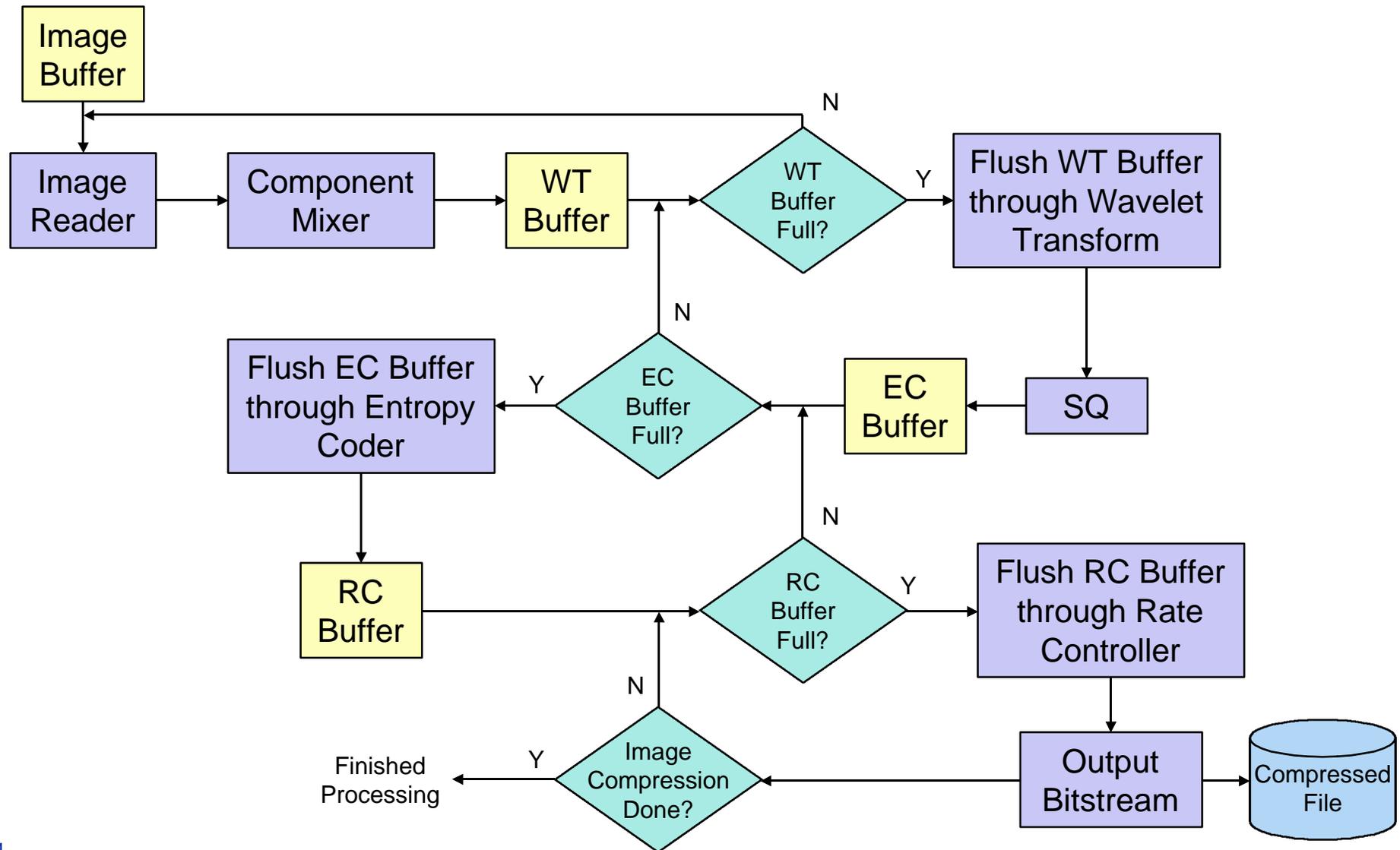


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- Part 1 (Core Coding System)
  - Contains features all decoders must support
    - ◆ (9x7) and (5x3) wavelet filters, Mallat decomposition
    - ◆ Scalar quantization
    - ◆ 3-component color space transforms
  - Became International Standard (IS) in December 2000
- Part 2 (Extensions)
  - Technologies for special applications
    - ◆ More complex than Part 1
    - ◆ Potentially subject to license fees
  - Decoders may support any one extension, or a combination
  - Became IS in December 2001

- Low-memory implementation designed for remote sensing applications
  - Can be used in downlink from spacecraft
- Processes image as a series of “scan elements”
  - Each scan element corresponds to 8 to 64 lines in image space
  - Scan elements may be tiles or precincts
- Implemented by SAIC for Part 1 in July 2000
  - Biggest change was in rate control buffer

# Block Diagram of Scan-Based Processing in Part 1



# Part 2 Features Useful in Remote Sensing

- Wavelet transform
  - Arbitrary filters
    - ◆ Longer filters useful for SAR data
  - Arbitrary decomposition structures
    - ◆ More detailed tree gives better quality for SAR data
  - Single Sample Overlap
    - ◆ Reduces boundary artifacts in tiles
- Multiple component transforms
  - Arbitrary linear transforms
  - Wavelet transform in third dimension
  - Needed for multispectral/hyperspectral data
- Implementation in scan-based mode requires optimization of memory management

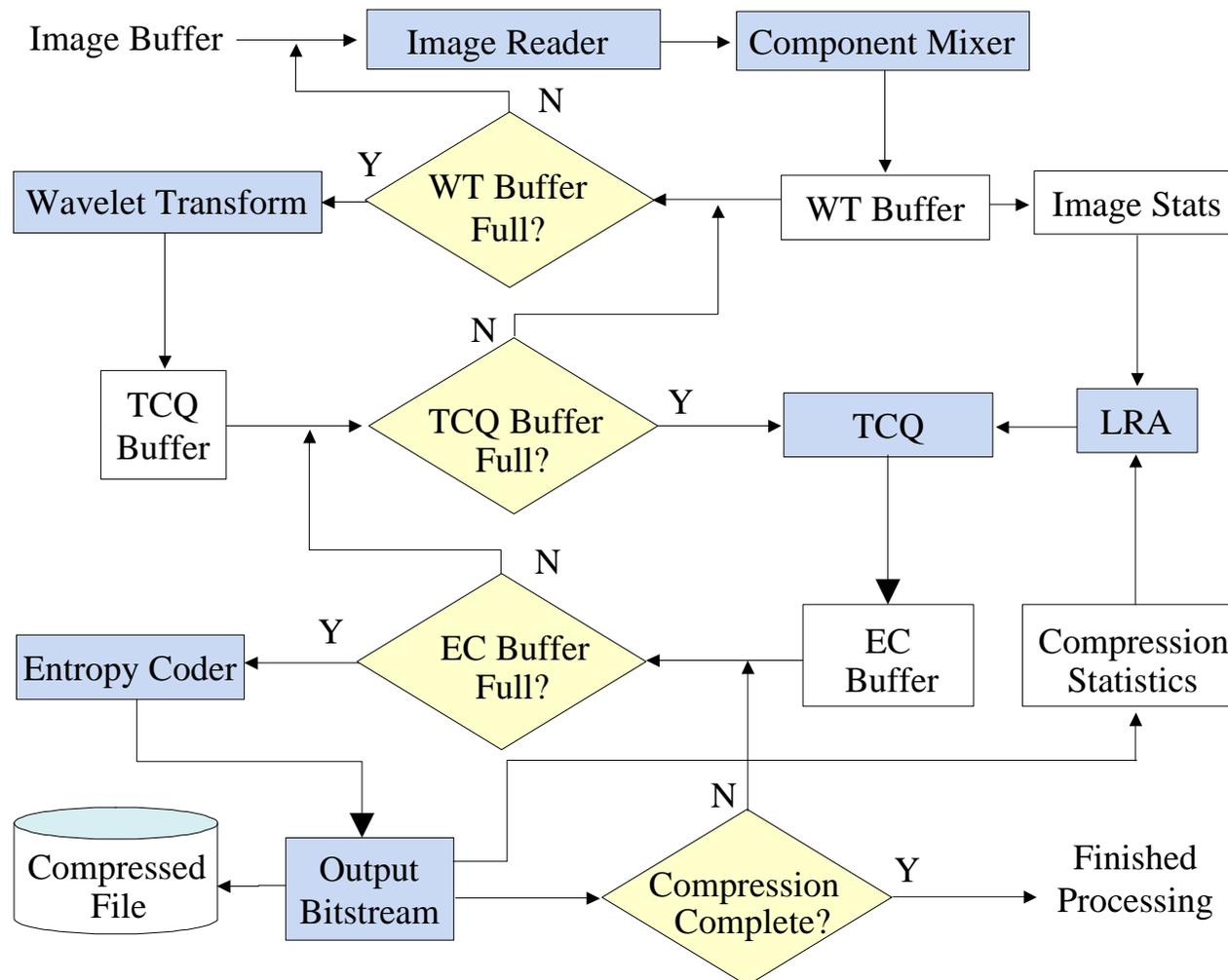
# Part 2 Features for Remote Sensing (cont'd)

- Trellis-Coded Quantization (TCQ)
  - Produces better visual quality than scalar quantization (SQ)
  - Recommended for detected SAR imagery
  - More complex than SQ
  - Useful in some remote sensing situations
- Lagrangian rate allocation (LRA)
  - Normally used with TCQ
  - Sets TCQ step sizes based on image statistics
  - Iterates until achieving desired bit rate
  - Must be modified for scan-based mode

# Scan-Based Implementation of TCQ

- Modifications to LRA
  - Collect image statistics on one scan element at a time
  - Eliminate iteration
  - Use rates achieved from previous scan elements to adjust step sizes on current scan element
  - Monitor compression statistics to maintain desired average bit rate by changing LRA “target rate”
- Separate step sizes are required for different scan elements to achieve TCQ rate control
  - Step sizes must change on a precinct by precinct basis
  - Requires syntax change in JPEG 2000 Part 2
  - Amendment to Part 2 implements required syntax change

# Block Diagram of Scan-Based TCQ

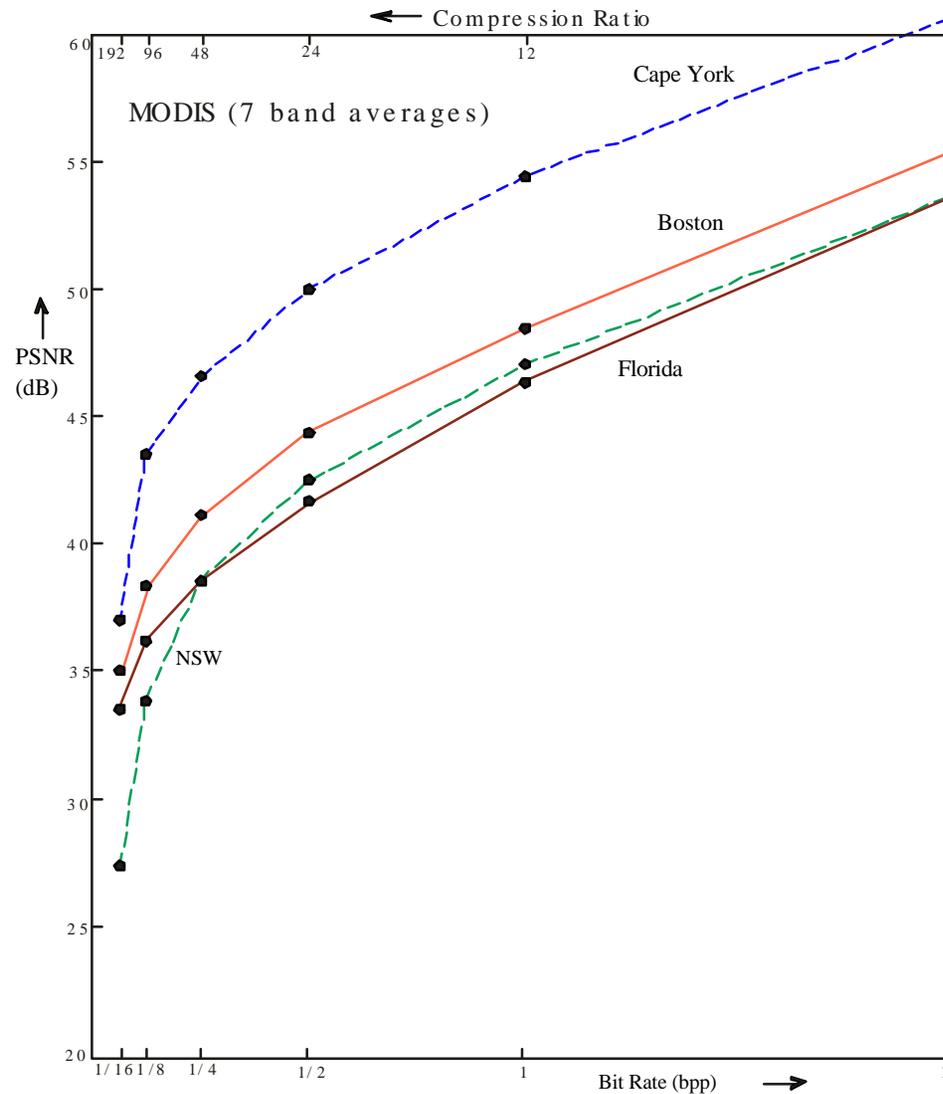


- Scan-based implementation completed by SAIC in December 2001
- Thorough testing under way in laboratory environment
  - Verify operation of all Part 2 features
  - Determine lossless compression ratios
  - Compute statistical image quality metrics (e.g., PSNR)
  - Perform visual image quality evaluations
  - Compare performance with other algorithms
- Test images
  - Taken from JPEG 2000, CCSDS, and other test sets
  - EO (panchromatic), IR, SAR, MSI, HSI
  - Collected by aircraft and satellites

# Preliminary Results: Lossless Compression

Name	Ratio
Panchromatic	
Aerial 1	2.21
Aerial 2	1.45
Spot LA	1.88
Hungary	2.44
Camp Lejeune	2.55
Kamchatka	1.73
Russia	2.07
Thermal IR	
Camp Lejeune	3.92
Hungary	3.63
SAR	
Pentagon	1.20
Stadium	1.50
MSI	
New South Wales	1.56
Cape York	1.70
Florida	1.52
Boston	1.64
Hungary	2.18
Camp Lejeune	2.49
Phoenix	1.68
Yuma	1.66
Spot LA	1.59
Forest	2.45
Ice	2.45
India	2.23
North Atlantic	1.90
Ocean	2.27

# Preliminary Results: PSNR for MSI

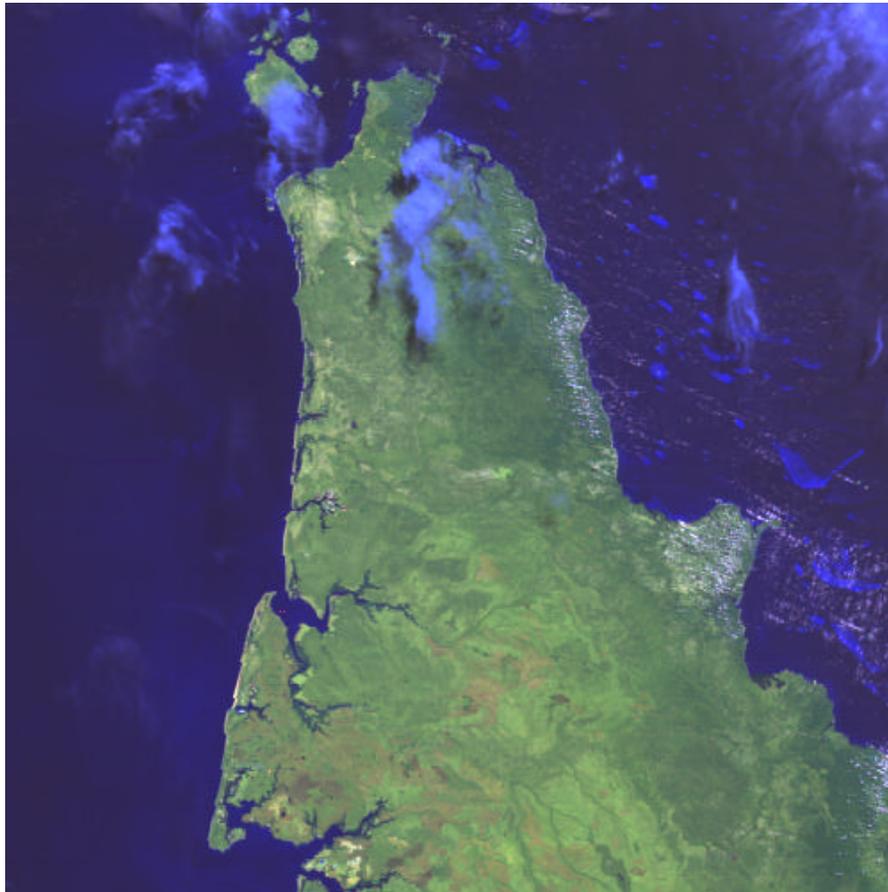


# Results from Variations in Test Procedure

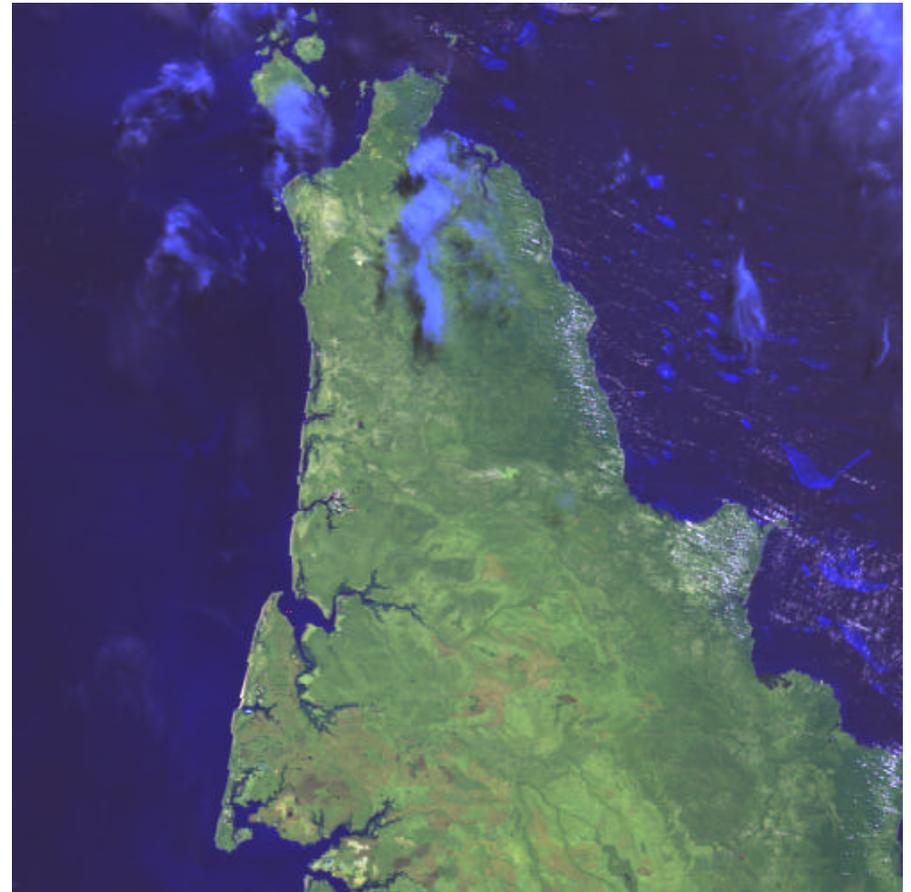
- Cost of 8-line scan elements vs. 64-line scan elements:  
<0.5 dB at moderate to high bit rates
- Cost of inserting up to 50 quality layers (for later re-transmission in quality progression order) <0.5 dB
- Use of TCQ vs. SQ
  - Slight loss in PSNR at lowest bit rates
  - Gain of about 1 dB at high bit rates
  - Visual quality gain expected to be greater

# Image Quality Example

## Cape York



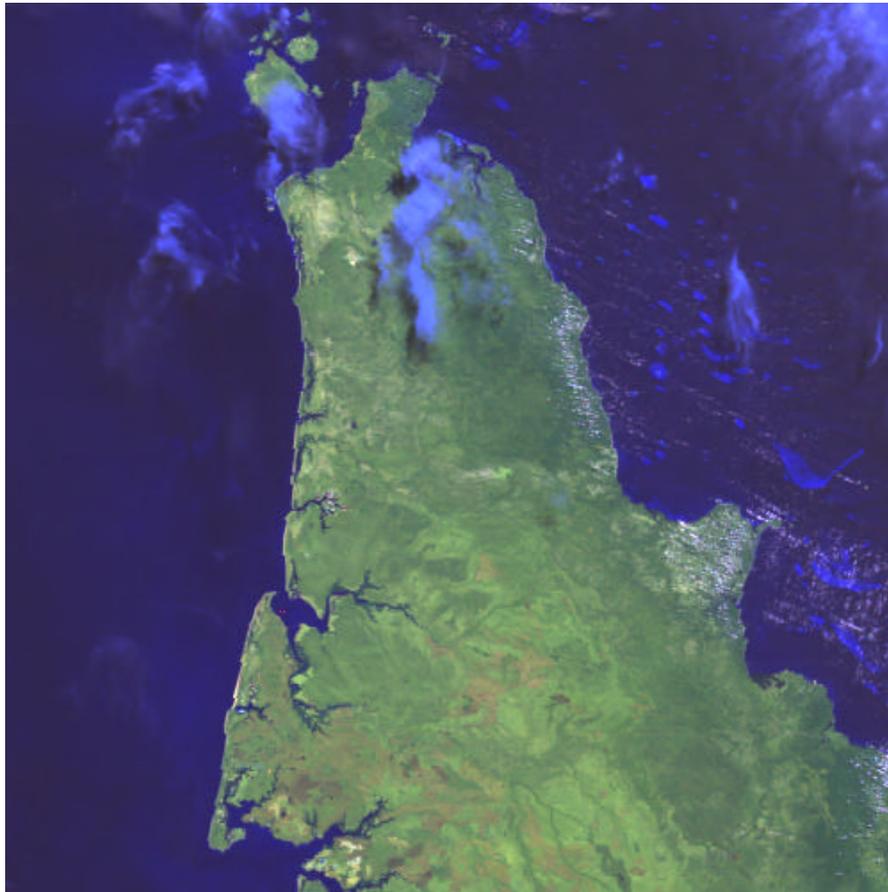
Original



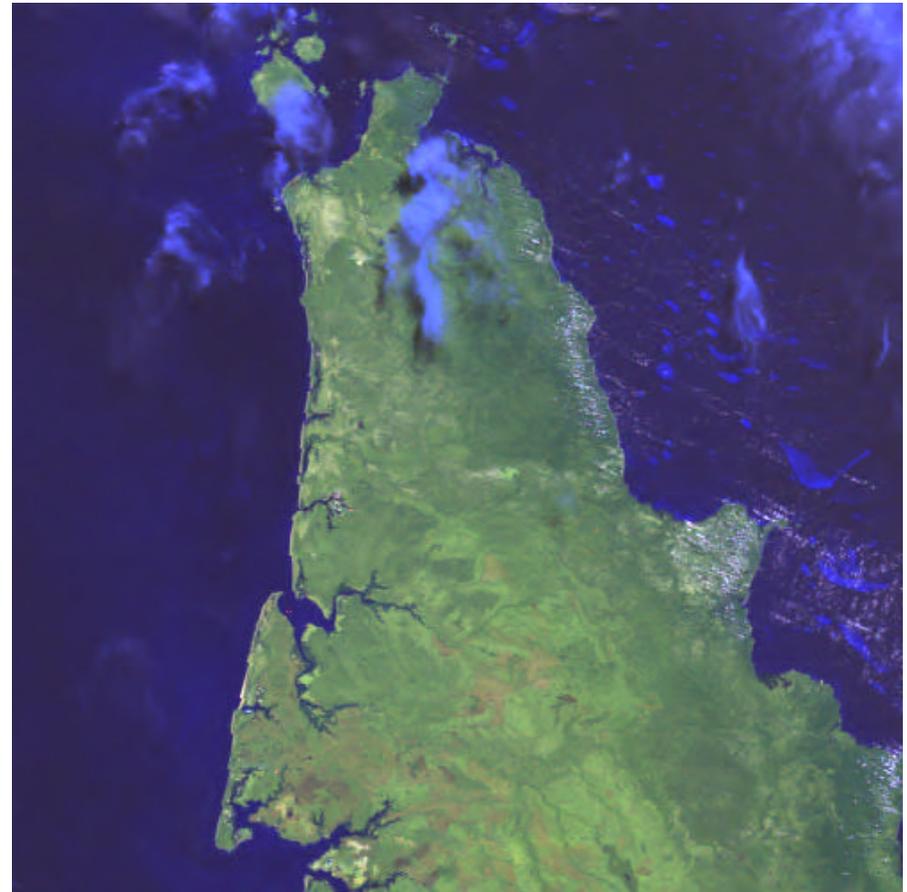
2.0 bpp

# Image Quality Example (cont'd)

## Cape York



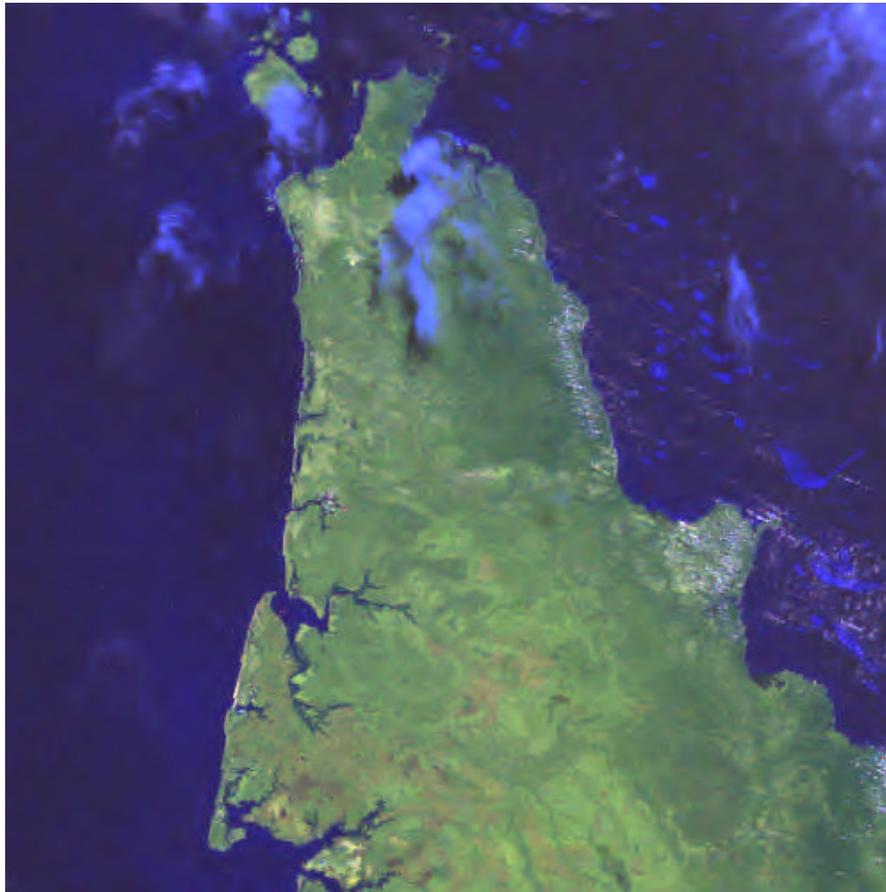
1.0 bpp



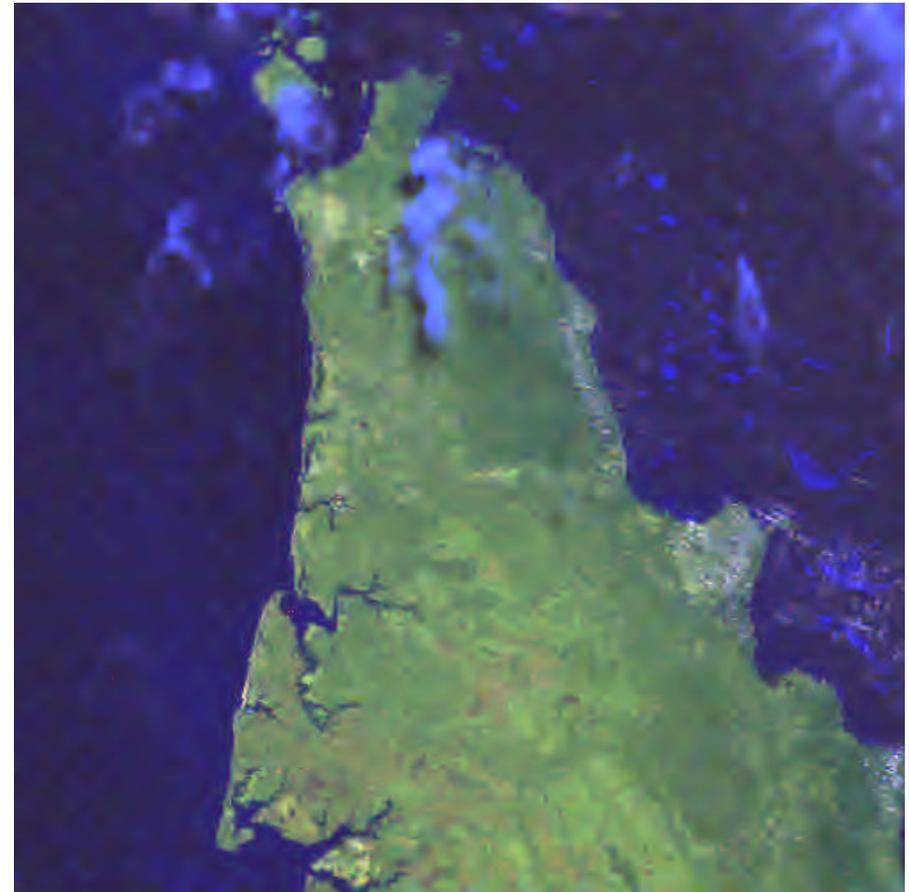
0.5 bpp

# Image Quality Example (cont'd)

## Cape York



0.25 bpp



0.125 bpp

# Status Summary

- A scan-based mode of JPEG 2000 has been implemented by SAIC
  - Designed for low-memory applications such as downlink from spacecraft
  - Includes both Part 1 and Part 2 features
- Software is currently being tested in a laboratory environment
- Next step is porting to a flight simulation environment