N-Color Work at Onyx Graphics

ICC DevCon 2020 - The Future of Color Management

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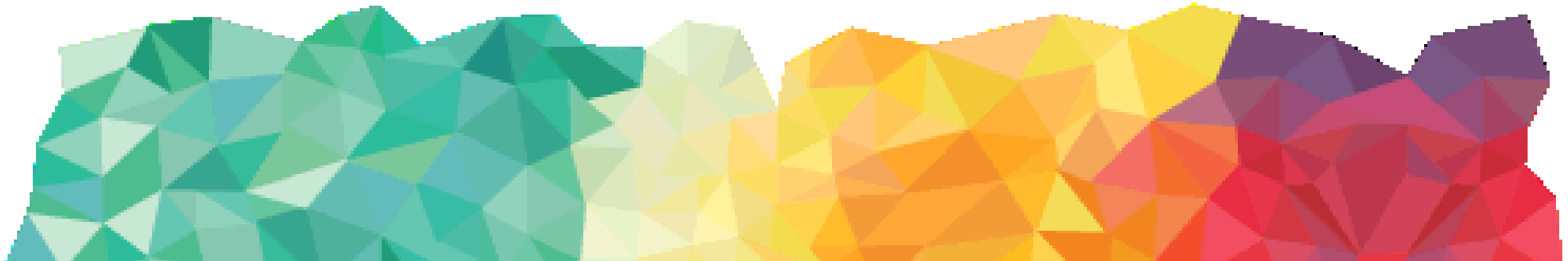
ONYX color

Outline

- Brief Introduction
- Ways of thinking about N-Color
- N-Color challenges
- N-Color processing and profiling pipelines
- Future opportunities with N-Color



A little bit about Onyx Graphics, Inc.

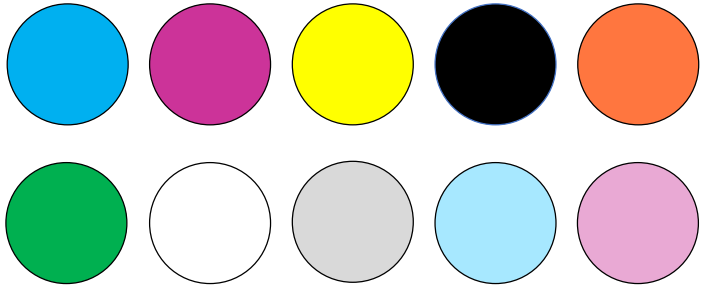
- Started in December of 1989
- Develops RIP Software for driving wide/grand format printing devices
- Support for
  - Over 2600 print devices
  - Thousands and thousands of combinations of Media+Colorant
- Technologies and applications
  - Aqueous
  - Solvent
  - Latex
  - UV Cured
  - Toner
  - Ceramic glazes
  - Textile Dyes
- Support for lots of different colorants on lots of different media

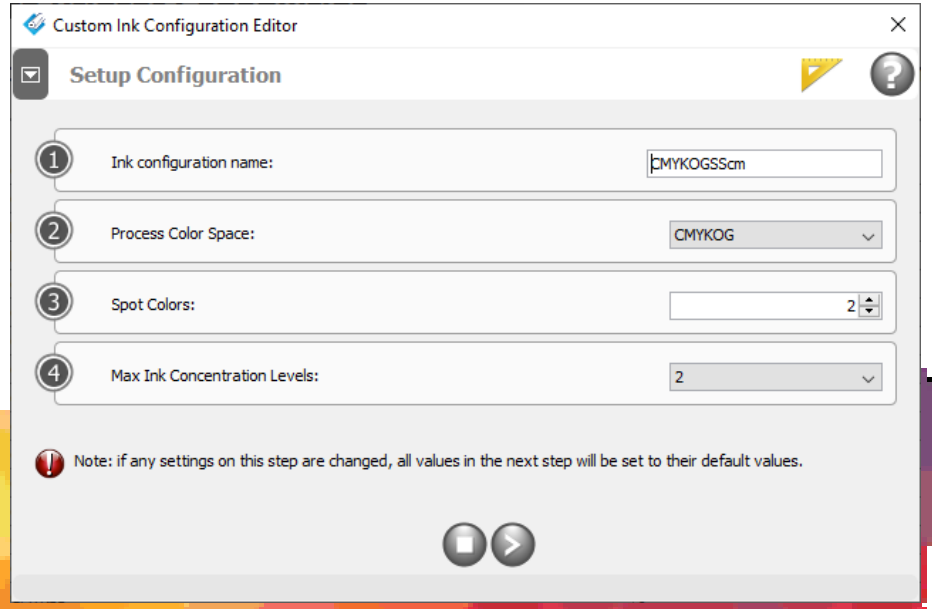
Why N-Color?

- Extending the gamut of colors that can be reproduced
- Better named color matching (spot emulation)
- Specialty applications
  - White for printing on film/colored media
  - Multi-Layer Printing
  - Draw attention and differentiate
    - Metallics
    - Fluorescence
- Provide competitive advantage

Thinking about N-Color

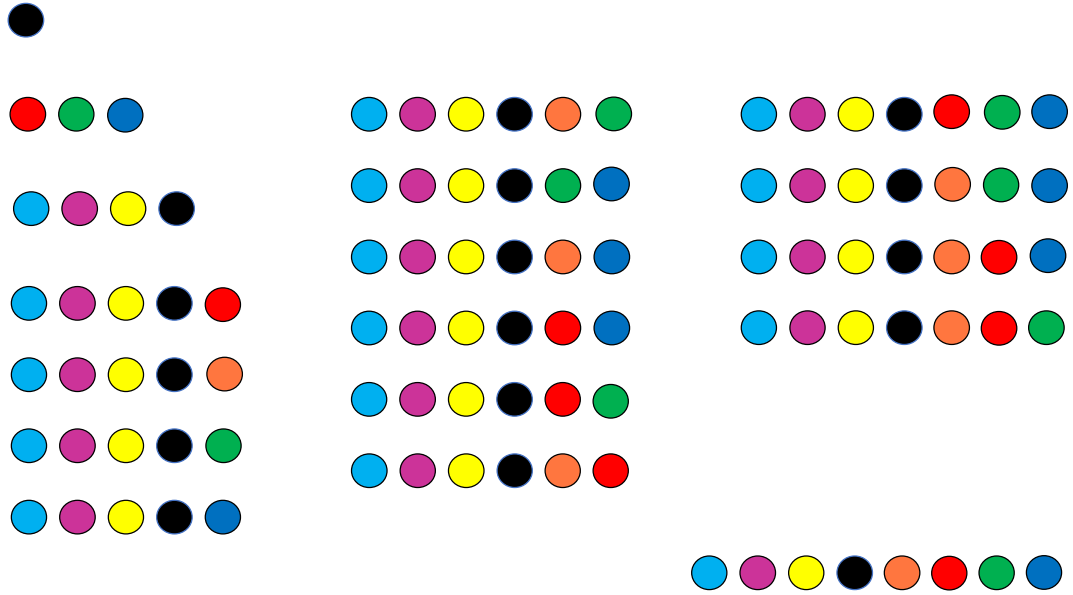
- At a printer device level
  - N-Color is realized by the ability to have output channels that are independently addressed and controlled
- At a software level
  - N-Color is separated into categories:
    - *Process Colors*
      - Have implicit color meaning and participate in color management
    - *Specialty (spot) colors*
      - White, metallics, gloss
      - Directly controlled by the image or document
      - Or job color tools are used to add spot layers
    - *Concentrations / dilutions*
      - Used to improve effective resolution
      - Can apply to either process or spot channels





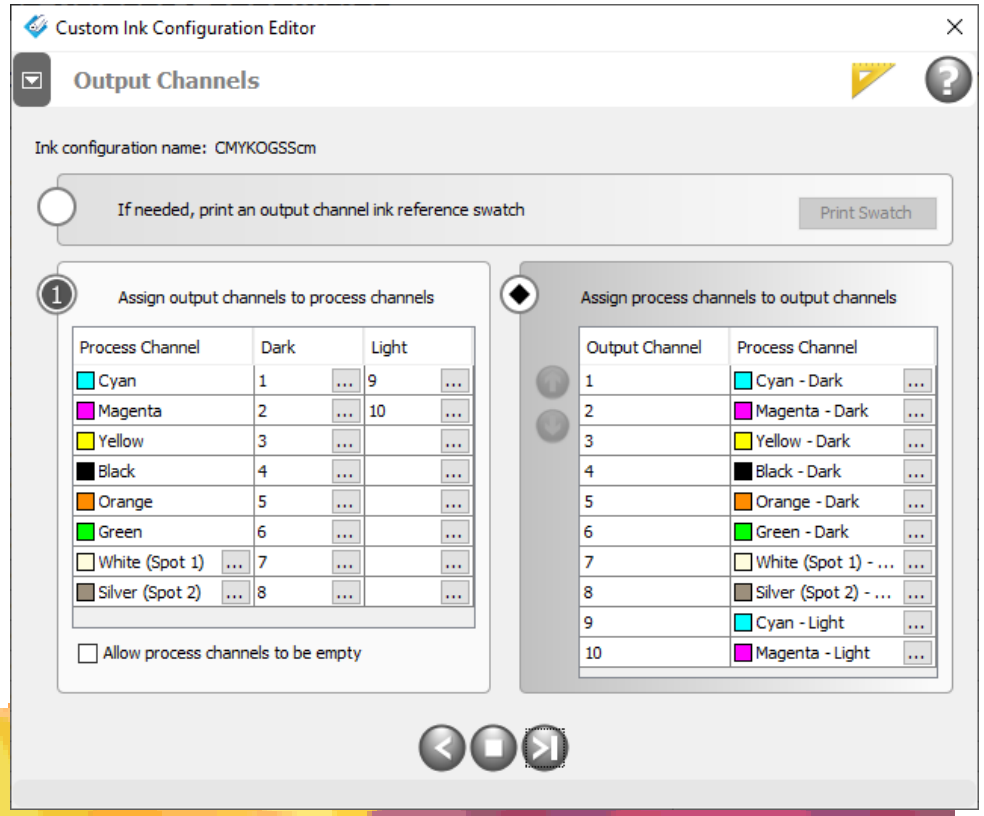
Onyx Process Color Spaces

- Internal native numeric conversions can be made between supported process color spaces
- This allows for flexibility in how color management is performed



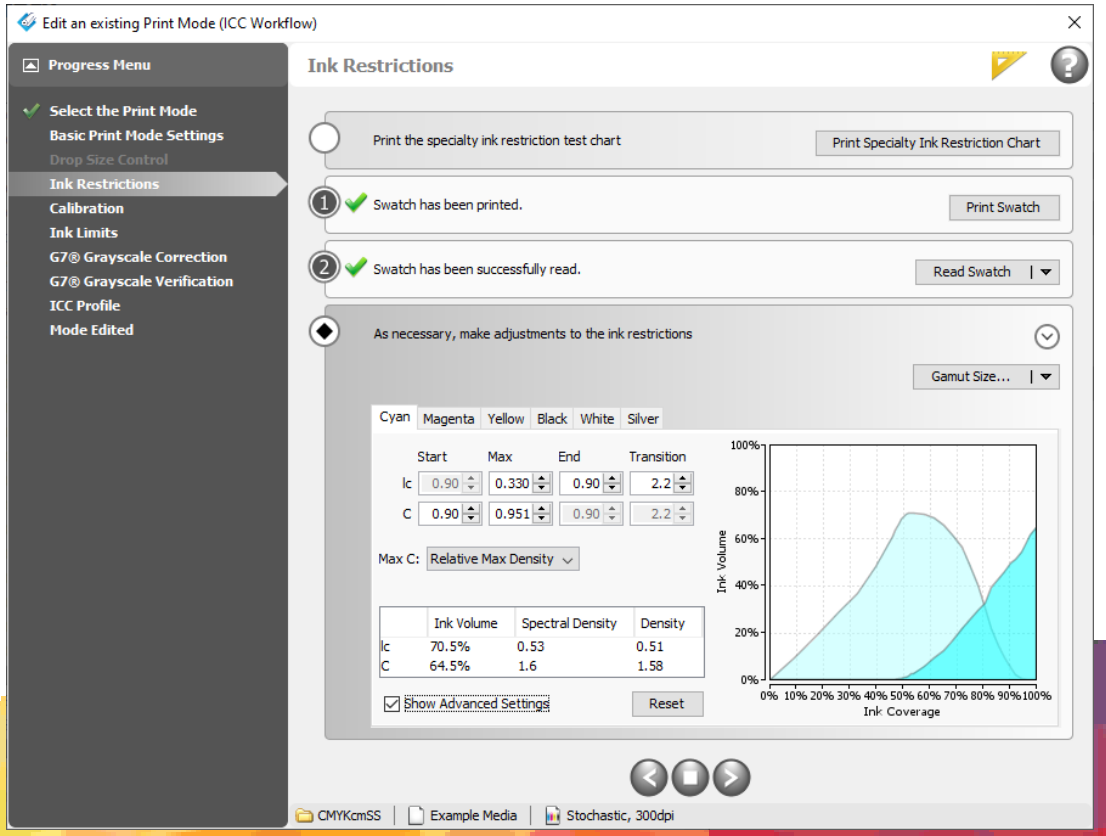
Establishing relationships between device output channels and software process channels

- Ink Configurations involve
  - Associating ink concentrations with processing channels
  - Associating software processing channels to printer output channels



Profiling process with N-Color

- First step of profiling process uses automated process to define ink concentration separations as processing channels
- Remaining steps only deal with process and spot color channels
- Note: Special care needs to be taken for spot channels that cannot be measured

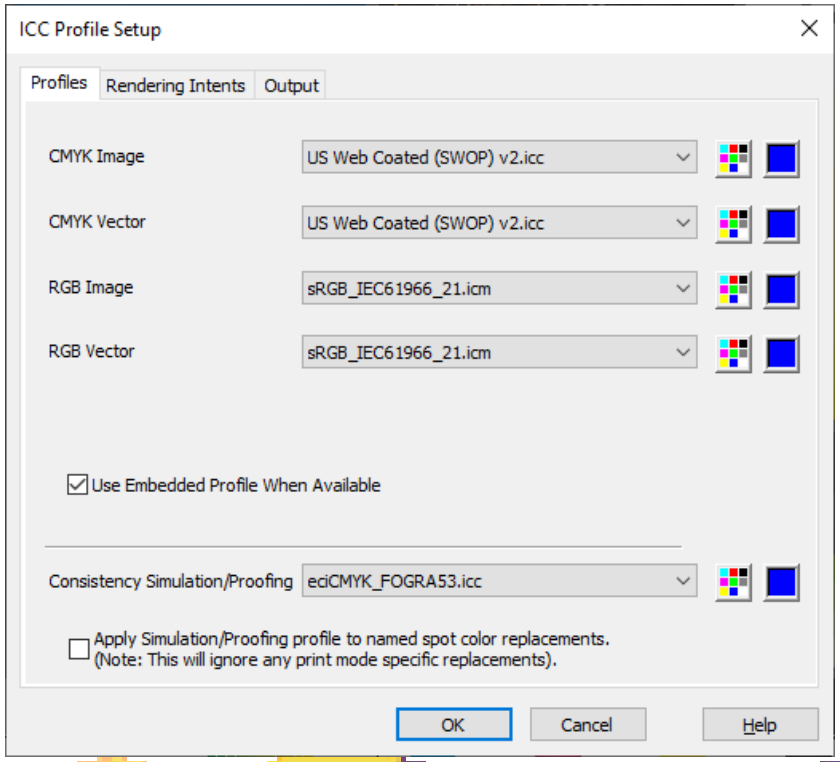


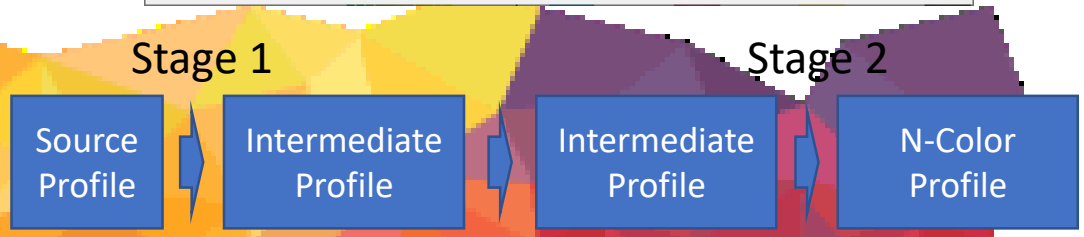
Challenges of N-Color

- Requires new and wider pathways to work with color pixels
- More information is needed to keep track of things
  - Number of channels is not sufficient
- PDF limitations
  - Source can generally be Grayscale, RGB, or CMYK
  - Complicates transparency processing
- Exponential increase of color combinations (see example)
  - Complicates swatches and n-dimensional look-up tables
- Complicates ink separation and color conversion (see example)

N-Color and PDF

- Problems can occur when using an N-Color output device with PDF
  - Transparency rendering in the device N-Color space is ill defined resulting in undesirable output
- Two stage processing can be used to addresses this problem
  - First RIP to a large gamut intermediate CMYK space (Simulation/Proofing) profile for proper rendering
  - Then convert to N-Color using color management

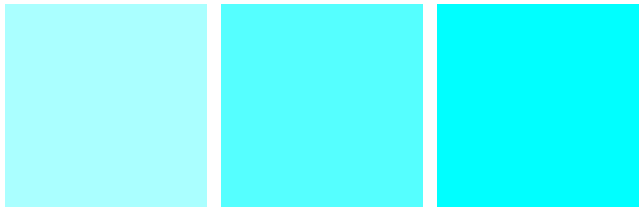




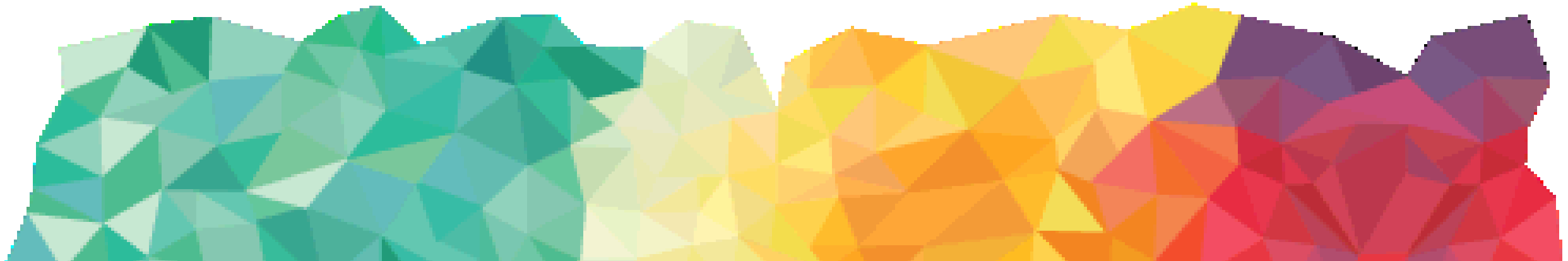
N-Color Dimensional Visualization

- The following slides show the exponential growth of a visual lookup table (LUT) as more dimensions are added
  - The contents of the LUT is visually represented with actual colors for each LUT entry
  - RGB colors are shown rather than Lab, XYZ or spectral values
- Only four steps are represented for each input channel dimension (0%, 33%, 66%, and 100%)

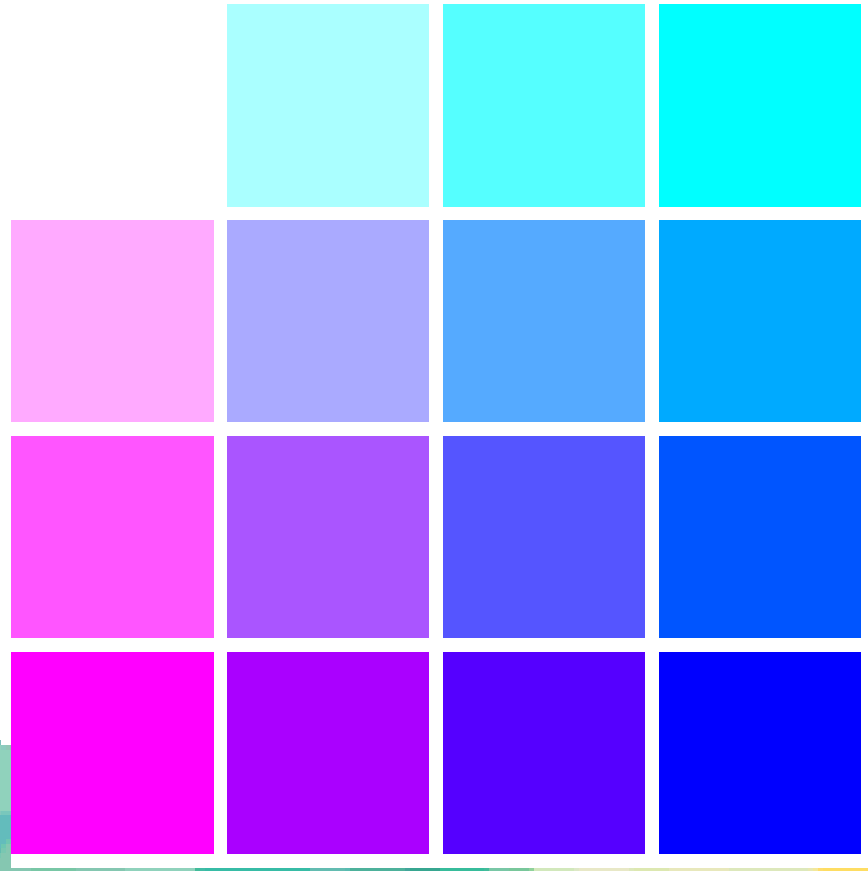
Example of Exponential Table Growth



- Colors:
  C
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4



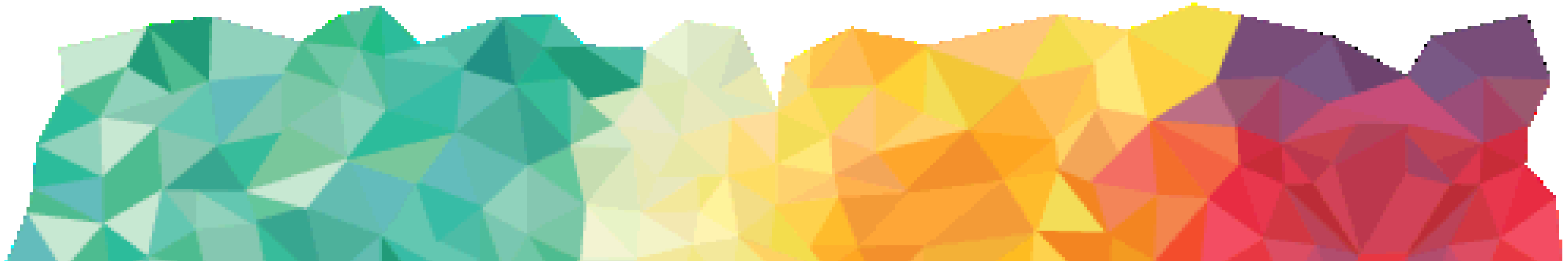
Example of Exponential Table Growth



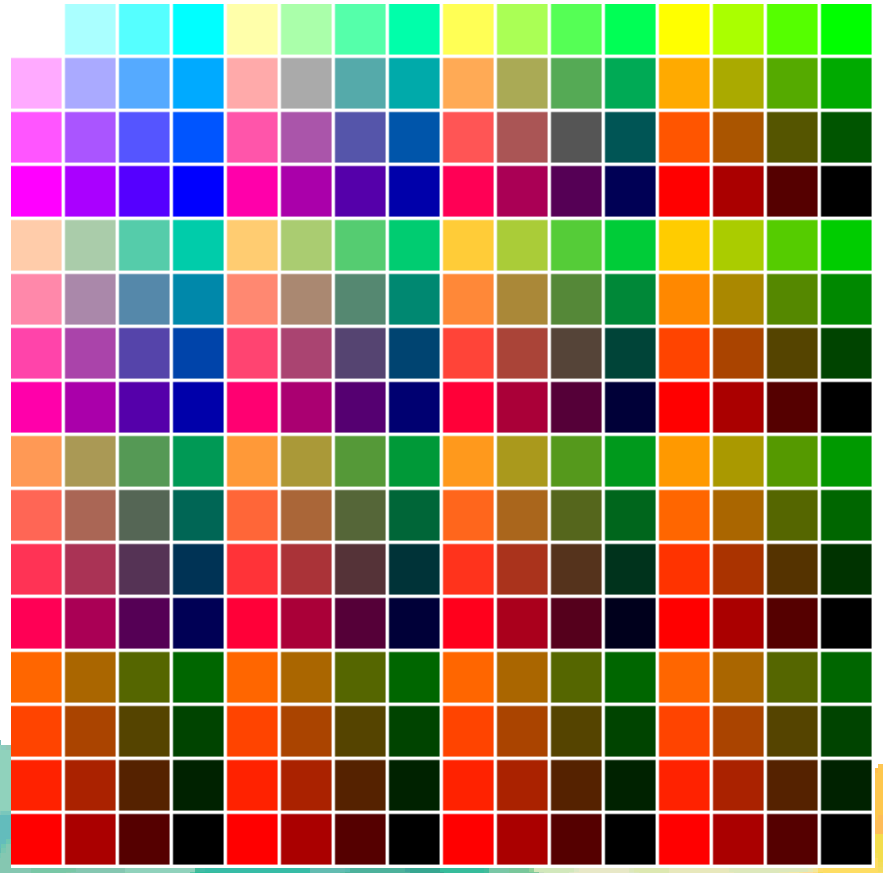
- Colors:
  CM
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4x4=16

Example of Exponential Table Growth

- Colors:
  CMY
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4x4x4=64

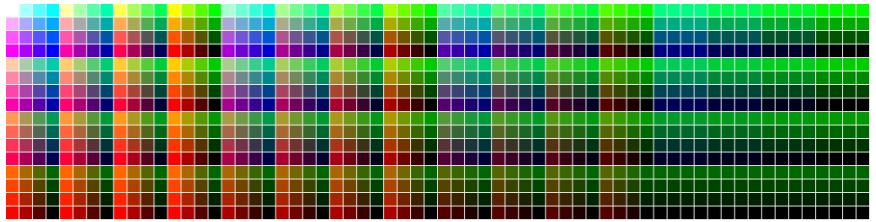


Example of Exponential Table Growth

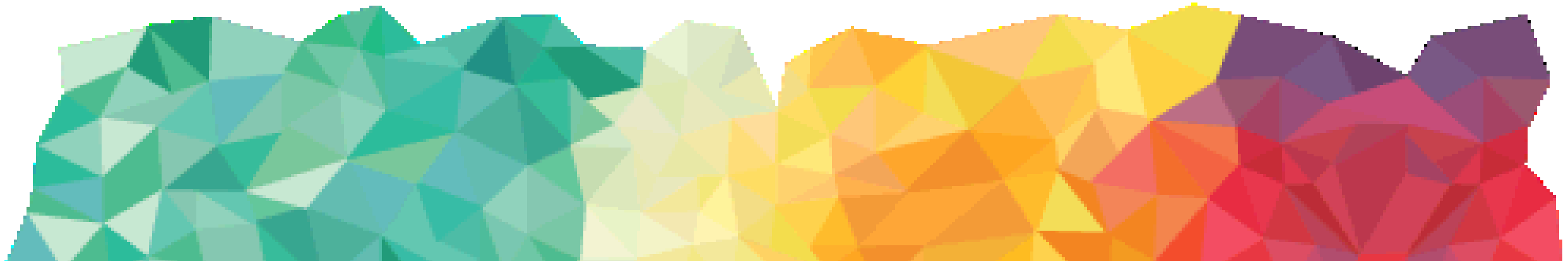


- Colors:
  CMYO
- Sampling:
  0, 33, 66, 100%
- LUT Size
  4x4x4x4=256

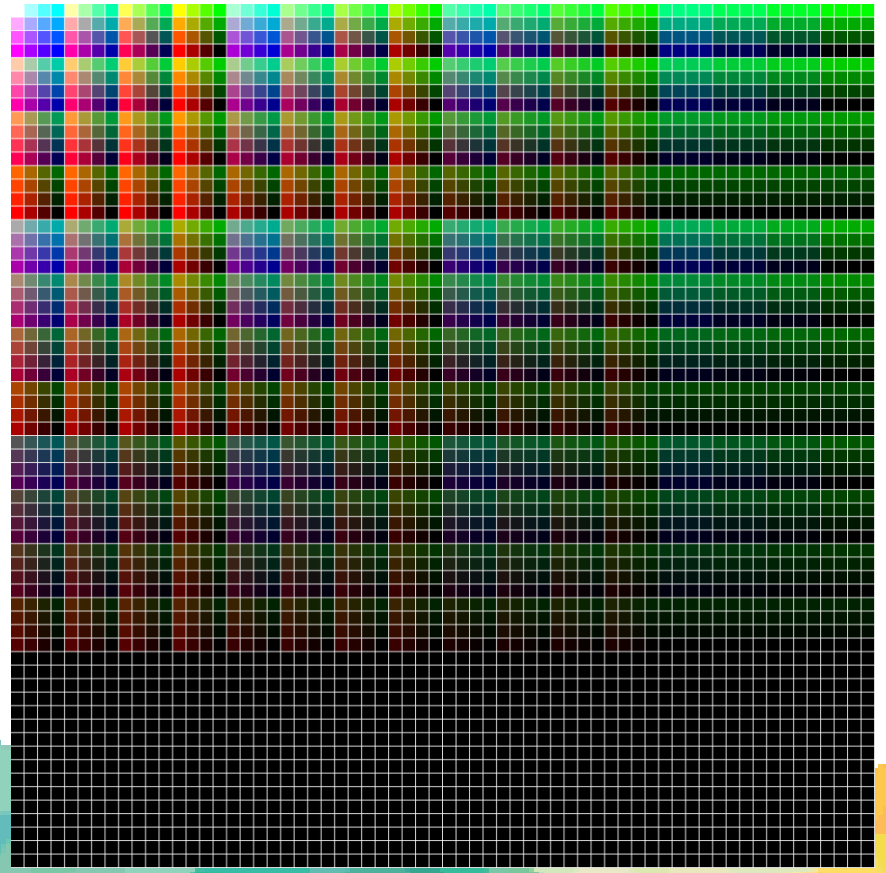
Example of Exponential Table Growth



- Colors:
  CMYOG
- Sampling:
  0, 33, 66, 100%
- LUT Size:
  4x4x4x4x4=1024



Example of Exponential Table Growth



- Colors:
  CMYOGK
- Sampling:
  0, 33, 66, 100%
- LUT Size:
  4x4x4x4x4=4096

Exponential Growth of N-dimensional LUTs

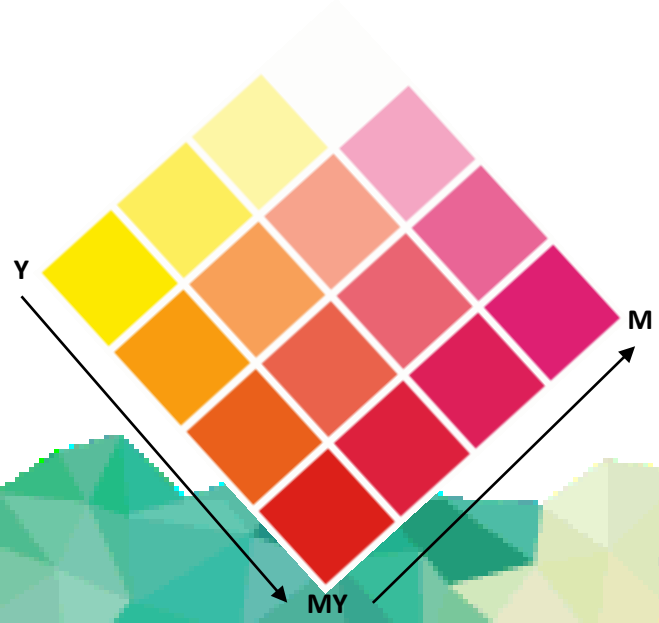
- In general terms, the number of entry points (E) in a look-up table (LUT) is defined in terms of the number of channels (N) and the number of sampling steps (S) by the exponential equation:

$$E=S^N$$

- E gets **really big**, **really fast** for each increase in N

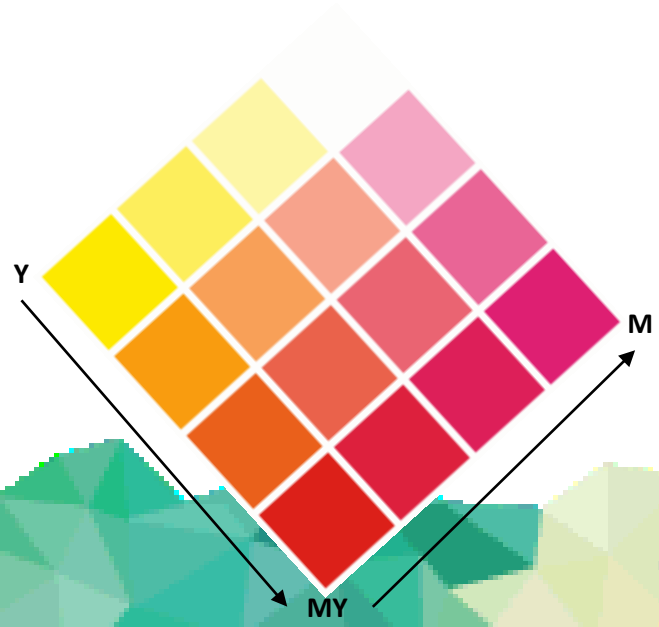
Multi-dimensional aspects of hue separation

Consider going from Yellow to Magenta

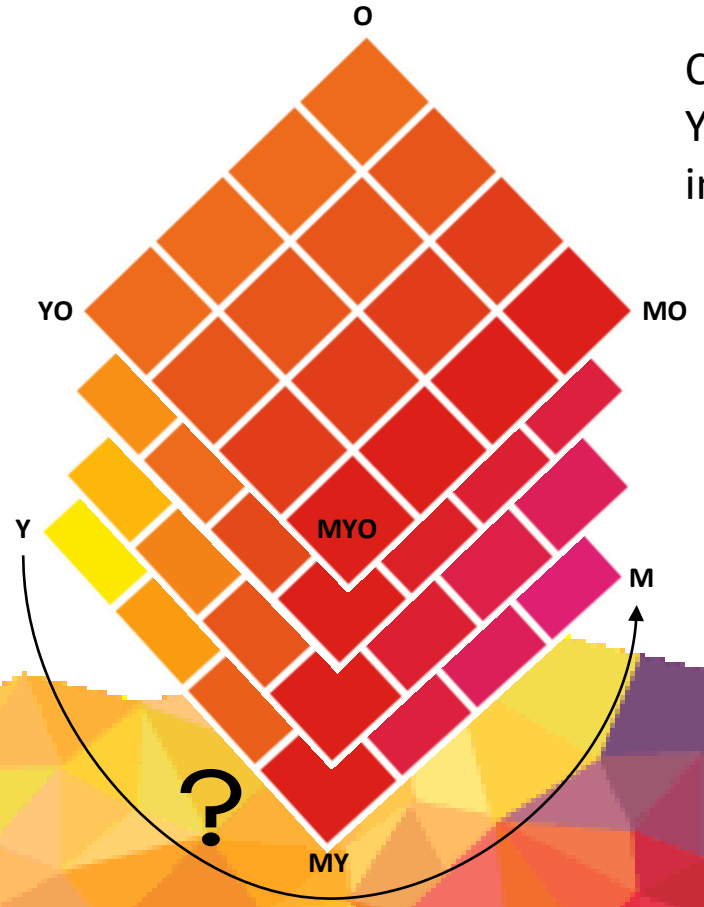


Multi-dimensional aspects of hue separation

Consider going from Yellow to Magenta

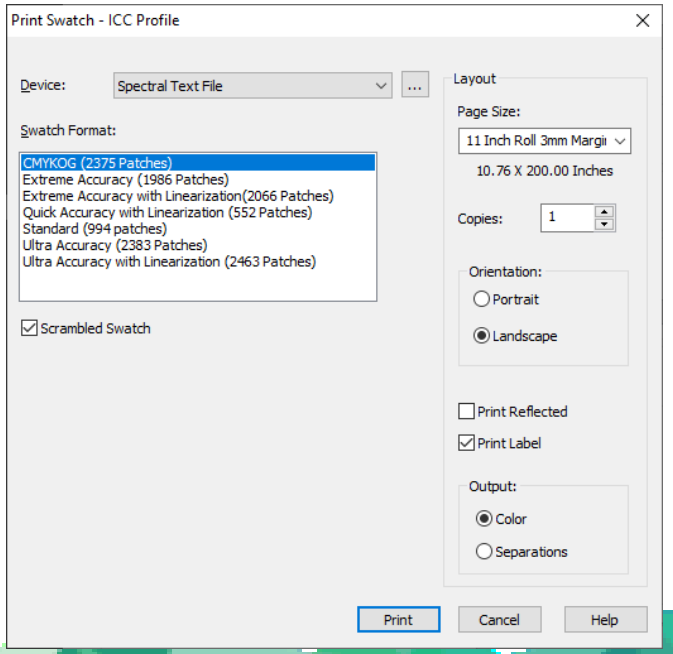


Consider going from Yellow to Magenta including Orange



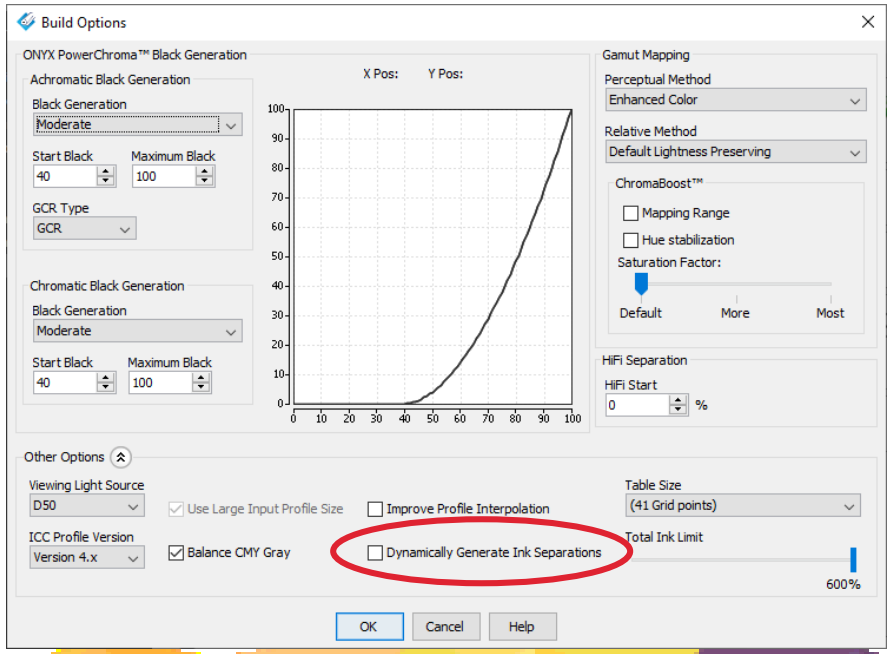
N-Color Profiling in Onyx Media Manager

Swatch Generation



- Swatch format selects between N-Color and Extended CMYK profiling approaches

N-Color Profile Generation Settings



- Can use pre-defined ink separation (smooth) or dynamic separation (to maximize gamut size)

N-Color Output Processing Pipelines

CMYK + N-Color Separation

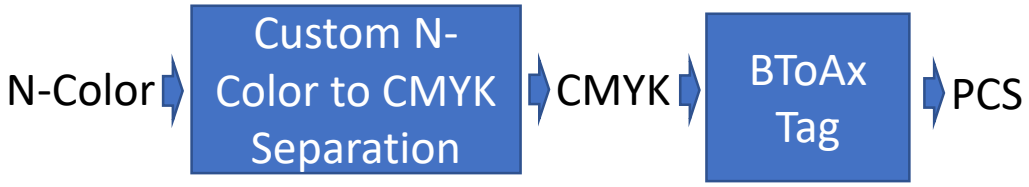
- Uses standard CMYK profiling mechanisms
  - Indicated by using CMYK swatch
- Separate custom CMYK to N-Color separation indicated in profile metadata
- Requires a custom CMM
  - Not an open, vender neutral, cross platform solution

Direct N-Color

- Requires N-Color Swatch
  - Indicated by using N-color swatch
  - Less sampling of full color space
- Separation to N-color is part of ICC profile
  - Larger Profile
- Uses standard ICC technology

N-Color Input Processing Pipelines

CMYK + N-Color Separation



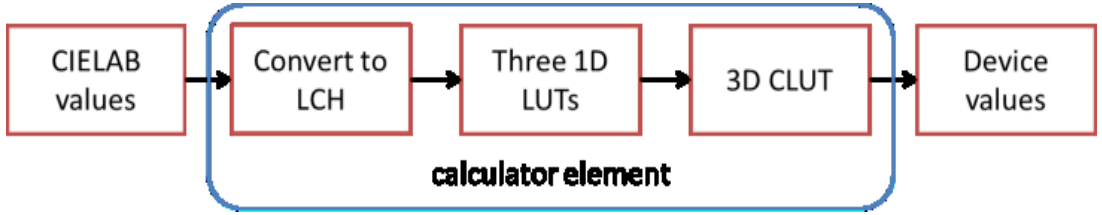
- Uses standard CMYK profiling mechanisms
  - Indicated by using CMYK swatch
- Separate custom N-Color to CMYK color conversion
  - May not represent actual colors
- Requires a custom CMM
  - Not an open, vender neutral, cross platform solution

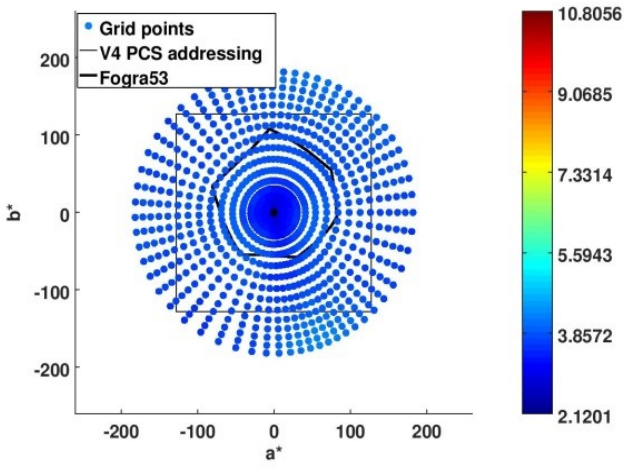
Direct N-Color

- Table grows exponentially relative to N
  - Represents actual colors
  - Less sampling of full color space
  - Indicated by using N-color swatch
  - Larger profile or less accurate profile
- Uses standard ICC technology

Current Use of iccMAX by Onyx Graphics

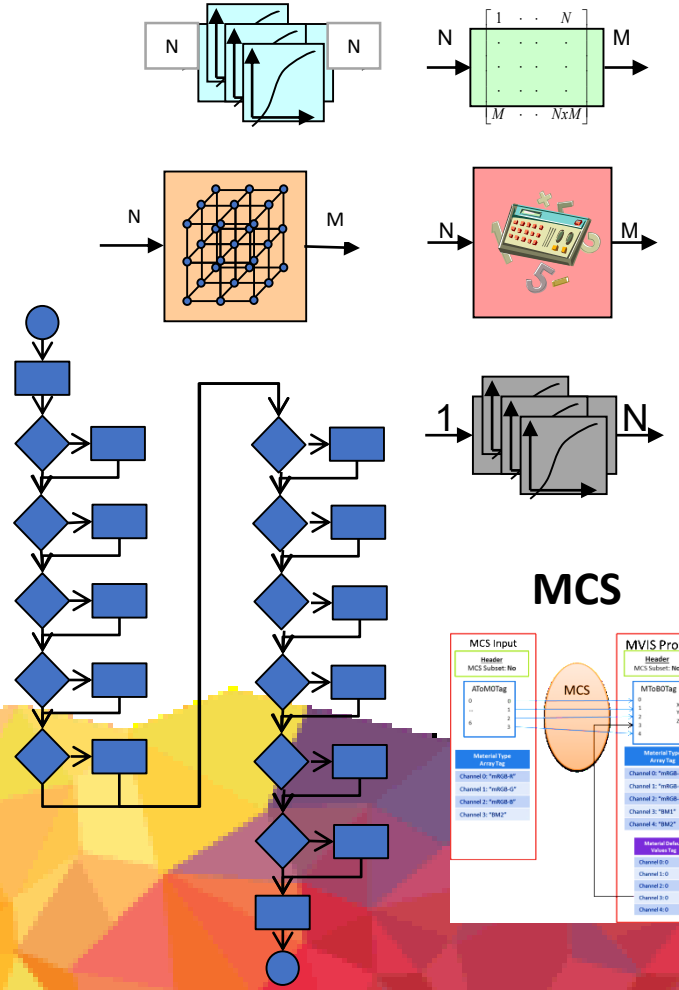
- Transforms are encoded in iccMAX using the MulitProcessElements tag type which provides a programmable transform mechanism
- Currently Onyx uses iccMAX to change the LUT color space to improve interpolation accuracy of output Tables





The Future of N-Color with iccMAX

- Options for determining output values from N-dimensional input values include:
  - Algorithmic:
    - Conditionally selecting and applying lower dimensional LUTs with higher sampling
      - Example: CMYK-3DLUTs.icc
  - Computational:
    - Directly encoding device/colorant math model
      - Example: ElevenChanKubelkaMunk.icc
    - Directly encoding of overprinting math model
      - Example: 17ChanWithSpots-MVIS.icc



- Note: The above examples can be found in ReflccMAX

Thank you for your kind attention!

Questions?