DGIWG 131

Printing Colours for Defence Geospatial Products

Document type:	Standard
Document date:	6 December 2022
Edition:	1.0
Responsible Party:	Defence Geospatial Information Working Group (DGIWG)
Audience:	DGIWG participants and associates
Abstract:	The Digital Printing Colour Profile defines standard printing terminology, printing ink colours and the digital equivalent to ensure NATO geospatial products are reproduced and digitally displayed with consistent colours.
Copyright:	

Executive Summary

The Printing Colours for Defence Geospatial Products, DGIWG 131, was developed by the Portrayal Technical Panel (PTP) to ensure consistent definitions, terminology and procedures for the hardcopy printing of NATO geospatial products (maps and charts). The standard is built upon the US MIL-STD-3060 Digital Printing Colors documentation. This describes printing inks and digital display equivalent values in Hexadecimal, RGB, CMYK and CIELAB colour models, in order to support vendor specific implementations of the commonly used colours on maps and charts. In addition to colour standardisation, this document serves as a reference for common techniques in colour application.

The content included in this document has been coordinated with geospatial Data Product Specification (DPS) subject matter experts across the NATO standardisation community in order to ensure that the definitions, terminology and colour values are consistently applied amongst the DPS development community.

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NOTE: All personal information will be removed when an internal document is made public. This includes names and personal e-mail accounts.

iii. Revision history

Date	Edition number	Primary clauses modified	Description
1 April 2021	0.1	DRAFT	Initial working DRAFT
2 Dec 2021	1.0	DRAFT	Final DRAFT approved by Portrayal Technical Panel and released for Quality Assurance
25 May 2022	1.0	DRAFT	Draft corrected to resolve Quality Assurance (P0) comments.
6 Dec 2022	1.0	DRAFT	Resolution of comments coming from the ballot.

iv. Future work

This standard shall be maintained and evolved in due course, in accordance with advances in the printing and digital display technology. Future versions should expand on printing formats such as PDF and Postscript.

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Introduction

This standard has been developed to ensure consistent definitions, terminology and procedures for the hardcopy printing of geospatial products (maps and charts) within the defence environment. It contains standardised colour definitions and is intended to be an authoritative reference for the development of other Defence Geospatial Information Framework (DGIF) and NATO Geospatial Information Framework (NGIF) artefacts in addition to NATO STANAGs and AGeoPs that address colours.

Besides colour standardisation the document serves as a training manual introducing common techniques in colour model applications, in addition to conversions amongst these models.

It is built upon the US MIL-STD-3060 Digital Printing Colors documentation which describes printing inks and digital display equivalent values in hexadecimal for web applications, RGB, CMYK and CIELAB, in order to support vendor specific implementations of the commonly used colours on maps and charts.

The content within this document has been coordinated with geospatial Data Product Specification (DPS) subject matter experts across the defence (DGIWG) standardisation community in order to ensure that the definitions, terminology and colour values are consistently applied amongst the DPS development community.

1. Scope

The scope of this standard is to define colour standards for the hardcopy printing of maps and charts within the defence environment.

2. Conformance

Any application or system, or data product specification claiming conformance to this standard, shall meet the criteria for conformance provided in the following abstract test suites:

1) For cartographic screen display and hardcopy map/chart printing within the defence environment, use Colour definitions

- As specified in Annex A

2) For conversions among various colour models, use Colour Conversion Processes

- As specified in Chapter 8

3) Use a correct colour terminology for DPS

- As specified in Chapter 4

3. Normative References

3.1. International Standards

ISO/CIE 11664-6:2014 Colorimetry — Part 6: CIEDE2000 Colour-difference formula

International Color Consortium, White Paper #5: Glossary of Terms, December 2004

3.2. National Standards

MIL-STD-3060, Digital Printing Colors with CHANGE 2, 2 November 2021

4. Terms, Definitions, and Abbreviations

4.1. Terms and Definitions

4.1.1. Halo

An outside stroke applied to raster, vector and text objects.

NOTE: Halo shall never be used to replace the term Stroke.

4.1.2. Mask

The visual hiding, obscuring or limiting of the visibility of an object or objects.

4.1.3. Opacity

A layer's overall opacity determines to what degree it obscures or reveals the layer beneath it.

4.1.4. Overprint

An object's blending setting that looks at the colour information in each channel and multiplies the base colour by the blend colour but does not alter objects of the same colour which are layered beneath it.

NOTE: In the DGIF/NGIF DPSs, the term Overprint should be changed to Overlap or Overlay when referring to situations where multiple objects are overlapping one another, causing legibility issues.

4.1.5. Transparency

Visibility of objects layered beneath an object with an overall opacity of less than 100%.

4.1.6. Other Terms and Definitions

Other terms and definitions used in the document have been taken from the references cited in the Normative References (Chapter 3) and Bibliography (Annex C).

4.2. Abbreviations

The following abbreviations are used in the document:

BMP	Bitmap
CAD	Computer Aided Design
CMYK	Cyan Magenta Yellow Key
DGIF	Defence Geospatial Information Framework
DOC	Microsoft Word Document
DPS	Data Product Specification
EPS	Encapsulated Postscript
GIF	Graphic Image Format
GIS	Geographic Information System
GML	Geography Markup Language
ICC	International Color Consortium
JPEG	Joint Photographic Expert Group
NGIF	NATO Geospatial Information Framework
PDF	Portable Document Format
PMS	Pantone Matching System
PNG	Portable Network Graphic
PPT	Microsoft PowerPoint Document
RGB	Red Green Blue
SHP	Shapefile
SVG	Scalable Vector Graphics
TAC	Total Accumulated Colour
TIFF	Tagged Image File Format

5. Applicability and Use

This standard is primarily designed to be referenced by other documents where colours are addressed.

6. Digital Elements and File Composition

In digital files, there are basic element types and file formats. Some file formats can facilitate different element types while others do not. Each file also has an associated colour space which determines the output intended for that file.

6.1. Basic Elements

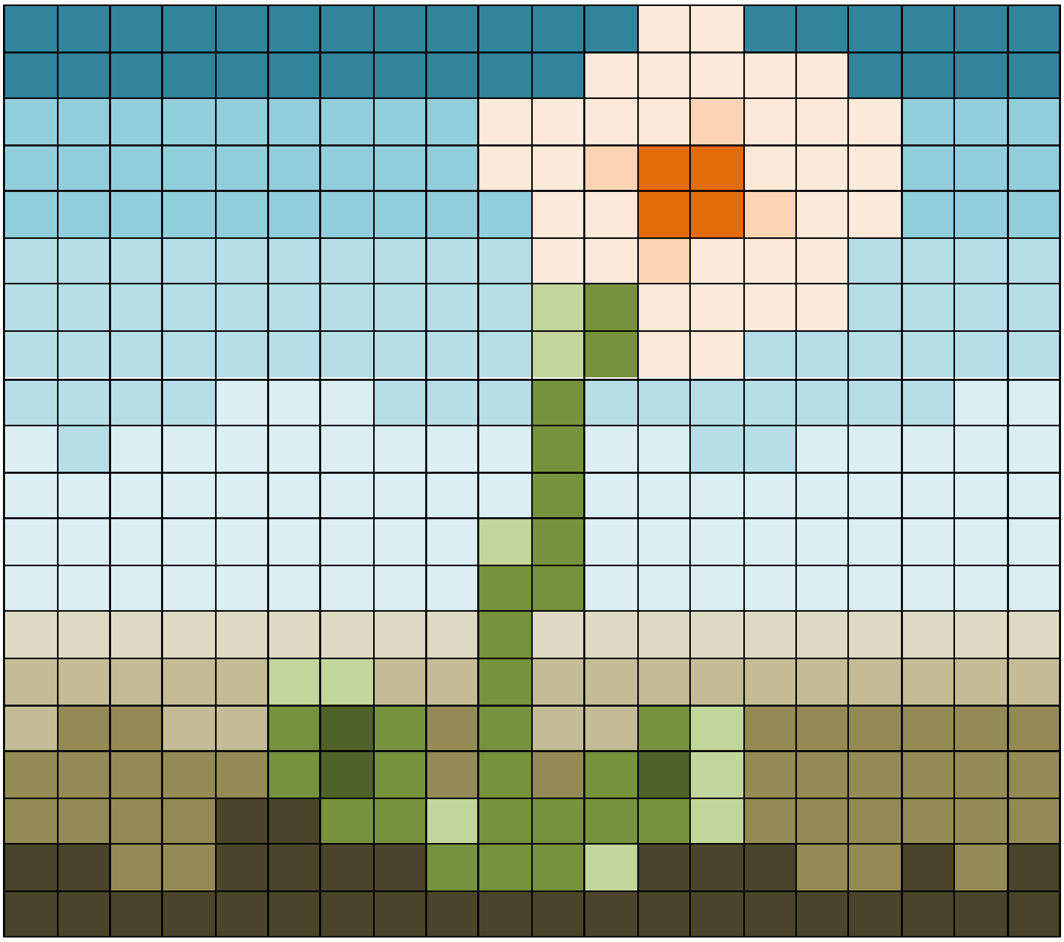
Files can consist of, or contain, three elements types: raster, vector and text. Each type has unique properties as well as advantages and weaknesses.

6.1.1. Raster

Raster is a grid or matrix of pixels and each pixel has an associated colour value.

Figure 1 shows an example of a 20x20 grid of pixels:

Figure 1: Grid of pixels – enlarged



When reduced to a relatively normal size, the above grid of pixels resembles an image of a flower, as shown in Figure 2.

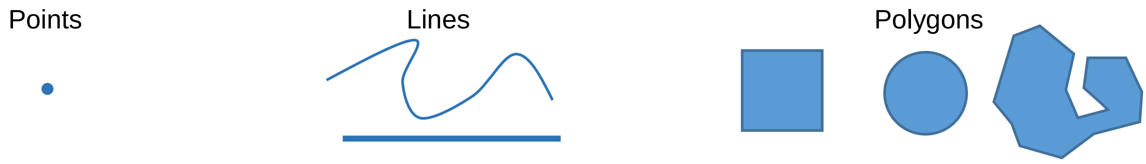
Figure 2: Grid of pixels – normal size

Raster resolution is determined and defined by the pixels per inch (ppi) or dots per inch (dpi) of a file (ppi for digital and dpi for printing) that are established within the file. For example, a 1"x1" file with a resolution of 300 ppi would be a grid of 300x300 pixels. A 2"x2" file with a resolution of 300 ppi would be 600x600 pixels.

6.1.2. Vector

Vector graphics are computer elements that are defined in terms of points on a Cartesian plane with three primary elements: Points, Lines, and Polygons, as displayed in Figure 3. Each element is composed of one or more of those three sub-elements. They are mathematically calculated so that the elements are infinitely resolvable at any zoom level.

Figure 3: Primary vector elements



6.1.3. Text

Text is typically any alphanumeric character displayed as individual letters or as strings of text. While text is really a subset of vector, it has unique characteristics that deviate from standard vector elements. Each letter or number is sourced from a font file where each character is portrayed with a vector element. This is why, when you shrink or enlarge text in word processing applications, it does not become pixelated or lose resolution. It is important to note that not all computers and systems have the same font packages installed. Therefore, it is critical that fonts are embedded within the files. This ensures that text within a file can always reach back to its source.

6.1.4. File Formats

Each of the above elements has file formats with which they are associated. While raster can typically be placed or rendered in various formats, vector objects typically can only be displayed or rendered inside a document format or in formats native for specific software application.

6.1.5. Raster Formats

Examples of raster file formats are as follows:

- Bitmap (BMP)
- Graphic Image Format (GIF)
- Joint Photographic Expert Group (JPEG)
- Portable Network Graphic (PNG)
- Tagged Image File Format (TIFF)

Raster formats *cannot* host vector objects. Thus, they are restricted to only include pixel-based information within the file structure.

6.1.6. Vector Formats

Vector formats are typical for graphics and Geographic Information System (GIS) applications as well as for Computer Aided Design (CAD) while both native and standard file formats exist. Examples of vector graphics formats are as follows:

- Scalable Vector Graphics (SVG)
- Encapsulated Postscript (EPS)
- Shapefile (SHP)
- Geography Markup Language (GML)

6.1.7. Document Formats

Page and Document file format examples are as follows:

- Microsoft Word Document (DOC)
- Portable Document Format (PDF)
- Microsoft PowerPoint Document (PPT)

These types of files have the ability to import/host raster, vector and text data. The drawback of document formats is, typically, the inability to perform comprehensive editing to the vector and raster objects within the document because other applications are usually required to execute the editing and modification of those objects.

PDFs are the primary document format to which map and chart products are exported. Because they can host a large variety of different objects, there are several types of file composition present within the PDF file format. Each requires a different processing and colour correction methodology. Identifying these variations will be covered in a later section of this document.

7. Colour Models and Spaces

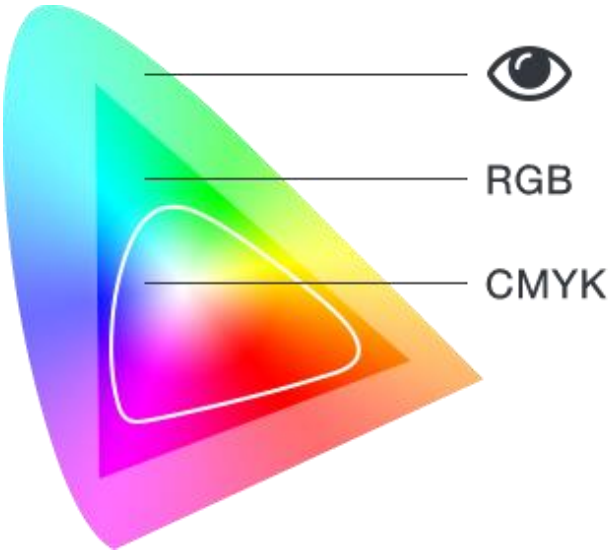
A Colour model is an abstract mathematical model describing the way colour can be represented as tuples of numbers.

There are three main types of colour models: RGB, CIELAB, and those used for print. RGB is used in digital displays and it stands for “Red, Green, Blue”. This denotes the colour of the elements that compose the individual pixels within a digital display. Print models are those used to output pigment or toner onto paper, or other substrates, in order to display colour. The most common Ink-based model is CMYK, however, there are also Spot Colours, which can be used in conjunction with, or independent from, CMYK. CIELAB is a model which encompasses all colours within the visible spectrum.

7.1. Colour Gamut

Colour gamut is defined as “solid in a colour space, consisting of all those colours that are present in a specific scene, artwork, photograph, photomechanical or other reproduction, or capable of being created using a particular output device and/or medium.”[1] As seen in Figure 4, the “horseshoe” shape represents the visible spectrum and the other boundaries represent which colours can accurately be portrayed in those colour models.

Figure 4: Visible spectrum and colour models[2]



[1] International Color Consortium, “White Paper #5: Glossary of Terms” 5.

[2] https://www.myprintsouth.com/blog.html/article/2018/01/22/designing-for-print-rgb-vs-cmyk

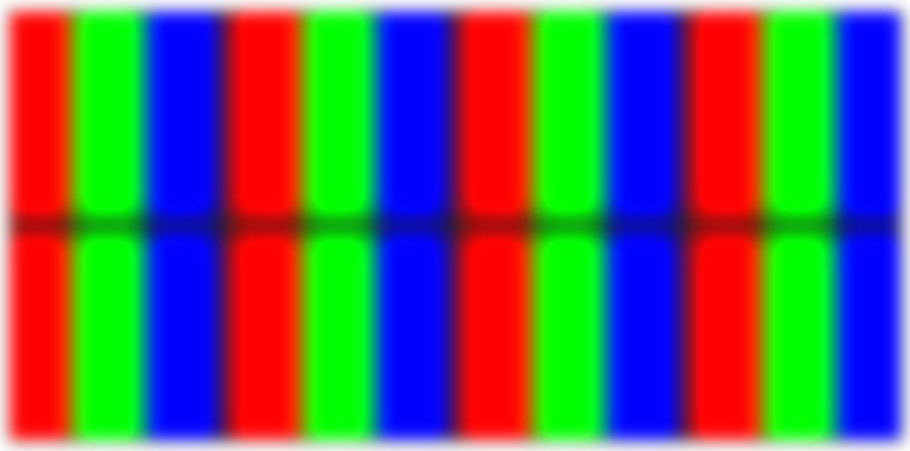
7.2. RGB Colour Model

The RGB Colour Model can be described as “a colorimetric colour space having three colour primaries (red, green and blue – RGB), such that CIE XYZ tristimulus values can be determined from the RGB colour space values by forming a weighted combination of the CIE XYZ tristimulus values for the individual colour primaries, where the weights are proportional to the radiometrically linear colour space values for the corresponding colour primaries. [ISO 12231]”[3]

RGB is meant for use on digital devices. While most commercial desktop printers can print a file that is defined as RGB, this is due to the device containing conversion tables and algorithms (i.e. ICC Profiles) so that the printed version looks similar to what is on screen. RGB is considered an “Additive System” which means that the more colour that is added, the lighter it becomes.

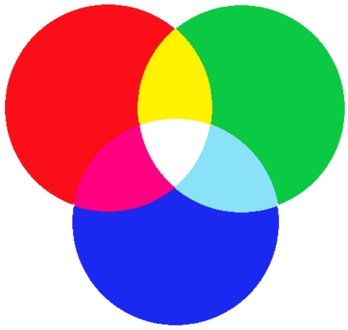
For example, an RGB value of 255 255 255 will result in a white pixel, whereas an RGB value of 0 0 0 will result in a black pixel. If you were to use a magnifying lens and place it up to a white display area of a computer monitor, you would see the pattern shown in Figure 5 (WARNING – staring at the below pattern may cause eye fatigue and headache).

Figure 5: RGB pattern



Despite seeing white on your screen, it is in fact a combination of three colours. The Additive colour combination of RGB values functions in a similar fashion to the example shown in Figure 6.

Figure 6: Additive colour combination of RGB values



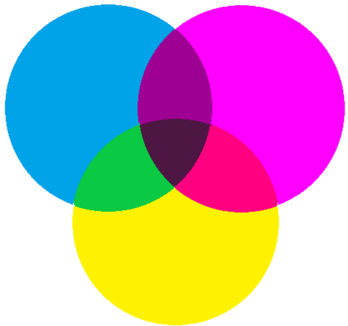
These three colours only apply to digital space. So, in order to translate this to a printed format, the file must be converted to a print-friendly colour system.

[3] International Color Consortium, “White Paper #5: Glossary of Terms” 1.

7.3. Print Colour Models

Ink and pigment-based colour systems are considered to be Subtractive. This means that the more pigment or ink that is added, the darker the resulting colour will be. Figure 7 shows an example of how Cyan, Magenta and Yellow colours mix in the Subtractive model.

Figure 7: Subtractive colour combination of CMY values



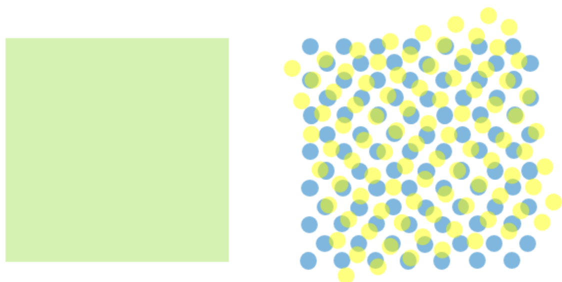
For many printing applications, CMYK is the primary colour combination. CMYK stands for Cyan, Magenta, Yellow and Key Colour, with K almost always representing Black. Most desktop printers contain CMYK ink or toner, however, other large format printers may contain additional colours as well. For example, the HP Z6810 plotter uses Cyan, Magenta, Yellow, Black, Light Cyan, Light Magenta, Light Grey, and Chromatic Red.[4]

Another example of the ink-based colour system is Spot Colour where "spot colours are single colorant, identified by name, whose printing tone-values are specified independently from the colour values specified in colour coordinate systems"[5]. Spot colours are pure and are not created through screened combinations of CMYK.

7.3.1. Screening – Halftone and Stochastic

Screening is the process by which printers assign dot patterns to simulate varying values of hue to the ares of colours that are printed. Figure 8 shows an example of how a green spot colour would be translated to CMYK and then screened and combined. The left square is the spot colour, while the right portion is a magnified area of the halftoned screened CMYK colour.

Figure 8: Spot colour translation to CMYK



The screened CMYK colour is made up of a combination of Yellow and Cyan dots which at print scale look to the viewer as if they are an area of solid green. At the zoom level shown in Figure 8, they appear absurd, but look acceptable when printed at high resolution on a printer.A minor colour shift should be expected like the smaller sample shownin Figure 9.

Figure 9: Printed Spot colour and CMYK samples

[4] https://store.hp.com/us/en/mdp/ink-toner/hp-designjet-z6810-60-in-production-printer

[5] International Color Consortium, "White Paper #5: Glossary of Terms" 1.

This is how almost all printing devices simulate colour. They derive the values of the digital file and convert them to dot pattern screens. There are several different ways of screening, such as stochastic screening methods (preferred) which use computer-generated random pattern of dots. This is different to legacy halftone screening methods using screen angles although the result is the same. Halftone dots of varying size and spacing create the illusion of solid and gradient colours.

Figure 10 depicts a halftone screen with a screen angle of 0 degrees applied portraying the rows of halftone dots aligning with the vertical when right-reading. The angle is measured clockwise with 0 degrees at 12 o’clock and changes depending on colour combinations.

Figure 10: Halftone dots standard screening

Stochastic/Frequency Modulation (FM) Screen (printing) is the method by which halftone dots are distributed on a pseudo-random basis, by which the frequency of dots affects the density of colour.

Figure 11: Halftone dots stochastic screening

7.4. CIELAB Colour Model

“XYZ tristimulus values and the associated Yxy colour space form the foundation of present CIE colour spaces. The concept for the XYZ tristimulus values is based on the three-component theory of colour vision which states that the eye possesses receptors for three primary colours (red, green, and blue) and that all colours are seen as mixtures of these three primary colours.”[6]

“In the 1940’s, Richard Hunter introduced a tri-stimulus model, “Lab”, which is scaled to achieve near uniform spacing of perceived colour differences.”[7]

“The L*a*b* colour space (also referred to as CIELAB) is presently one of the most popular spaces for measuring object colour and is widely used in virtually all fields. It is one of the uniform colour spaces defined by CIE in 1976 in order to reduce one of the major problems of the original Yxy space; that equal distances on the x/y chromaticity diagram did not correspond

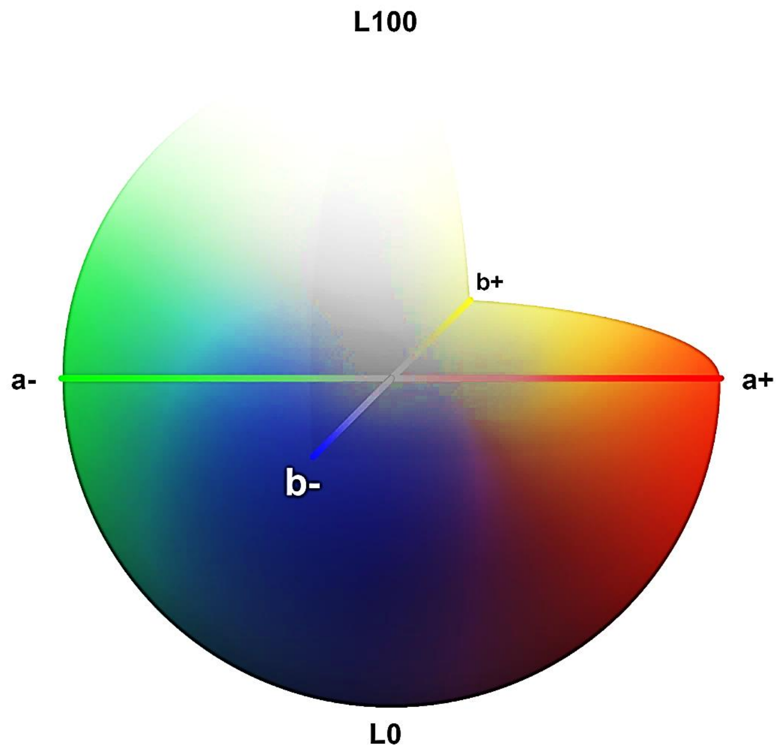
[6] https://www.konicaminolta.com/instruments/knowledge/color/part1/09.html

[7] https://www.xrite.com/blog/tolerancing-part-3

to equal perceived colour differences. In this space, L* indicates lightness and a* and b* are the chromaticity coordinates."[8]

The CIELAB colour model is a three-dimensional representation of the visible spectrum with "L," "a," and "b" acting as the three axes. "L" is the value for the lightness/darkness of a colour, with 0 being the darkest value and 100 being the lightest. Negative "a" values denote Green hues, while positive "a" values denote Red hues. Negative "b" values denote Blue hues, while positive "b" values denote Yellow hues.

Figure 12: CIELAB colour model



As seen in Figure 12, the greater the "a" or "b" absolute value, the more saturated the colour appears. Both "a" and "b" axes extend from -128 to +128. In addition, the closer to 0 a colour is on either the "a" or "b" axis, the less saturated that colour appears.

Within the CIELAB colour model, there are numerous formulae for colour tolerancing and determining colour differences. However, although "there are numerous ways to specify colour tolerances, one increasingly popular method involves using a total colour difference formula based on the CIELAB colour scale and differences in lightness, chroma and hue." That "total colour difference formula, CIE ΔE 2000, reportedly with significant improvements over the previous ΔE formulas (ΔE* CIELAB and ΔE CMC),"[9] was proposed by "CIE TC1-47 in CIE Publ.142 in 2001 and standardized in 2013."[10] "Since 2013, both ISO and IDEAlliance have adopted ΔE2000 as the new industry standard for calculating colour differences."[11] ISO/CIE 11664-6:2014 specifies the method of calculating colour differences according to the CIEDE2000 formula.

As seen from the conversion processes (below), CIELAB is used as the primary conduit for the translation of colour data amongst the various colour models. While CIELAB is very seldom

[8] https://www.konicaminolta.com/instruments/knowledge/color/part1/07.html
[9] Richard W. Harold, "An Introduction to Appearance Analysis" 1.
[10] https://techkonusa.com/a-simple-review-of-cie-%CE%B4e-color-difference-equations/
[11] https://techkonusa.com/a-simple-review-of-cie-%CE%B4e-color-difference-equations/

used as the final colour model (as RGB and CMYK are), it provides the quantitative standard for representing and evaluating the absolute value of a colour.

8. Colour Conversion Process

Converting colours typically has two main viewing options; on a digital device or on physical media. The processes for both are different as the viewing intent drives the method of conversion. The sections below explain how the ICC (International Color Consortium) profiles are used in the conversion processes, which conversion formulas are used in each process, when colorimeters are required and the limitations of converting colour amongst the various colour models.

8.1. ICC Profiles

"In general, ICC profile is a set of transformations from one colour encoding to another."[12] "Any ICC profile contains one or more tables to allow calculation between 'device colour space' ICC and XYZ or L*a*b colour space, or the opposite. Some ICC profiles do contain several tables to allow for conversion using different rendering options. However, all these tables do is provide for variants on the above calculations. L*a*b* or XYZ are used in ICC profiles as the Profile Conversion Space (PCS) because they are unequivocal. Each numerical value in either XYZ or L*a*b defines a single colour relative to human vision."[13] These profiles contain a somewhat simplified tabulation of the possible combinations of CMYK tints. For example, each CMYK ink has 100 possible values, resulting in 100,000,000 colour combinations. However, ICC profiles typically simplify the CMYK tabulation to only include combinations of every 10% gradation. This reduces the total colour combinations in the ICC profile to 10,000, where colour conversion data can be extrapolated from the less dense data sampling.
Ultimately, ICC profiles make it possible to convert files to different colour spaces. For example, when printing, the ICC profile can convert an RGB file to CMYK in order for the printer to output the file. Conversely, ICC profiles can also ensure that when a file is viewed on a monitor, the colour is rendered accurately.

8.2. Colorimeter

A colorimeter is an "instrument for measuring colorimetric quantities, such as the tristimulus values of a colour stimulus."[14] Examples of these devices are densitometers, spectrodensitometers, and spectrophotometers. Typically, these devices are laid on top of a printed colour swatch, the swatch is then illuminated with a designated illuminant setting and it then returns a CIELAB value.

8.3. RGB to CMYK

Converting RGB to CMYK typically requires an ICC profile. Because the viewing intent of CMYK is in printed format, there are a myriad of possible paper and ink combinations that must be accounted for which is what ICC profiles do. The RGB conversion process is as follows:

1. Convert RGB to XYZ.
2. Convert XYZ to CIELAB.
3. Convert CIELAB to CMYK.

Because the ICC profile contains a simplified tabulation of the CMYK to CIELAB values, it allows RGB to be converted to the closest possible colour representation in CMYK. Also, due to CMYK being the smallest colour gamut and cannot encompass the same colours as the

[12] International Color Consortium, "White Paper #5: Glossary of Terms".
[13] https://www.colourmanagement.net/advice/about-icc-colour-profiles
[14] International Color Consortium, "White Paper #5: Glossary of Terms" 5.

RGB colour model, there is typically a loss of colour vibrancy and saturation when RGB is converted to CMYK.

8.4. CMYK to RGB

Converting CMYK to RGB is somewhat the reverse of the RGB to CMYK conversions process:

1. Convert CMYK to CIELAB using a colorimeter.
2. Convert CIELAB to XYZ.
3. Convert XYZ to RGB.

Because RGB has a much larger colour gamut than CMYK, the RGB representation of the CMYK colour should be fairly accurate. In addition, rather than relying on a simplified tabulation, the colorimeter measures the *exact* value of the printed colour. This allows for a very accurate translation of the colour data between models.

8.5. Spot Colour to CMYK

Because most spot colour manufacturers test and evaluate which CMYK combinations best represent their spot colours, CMYK equivalents of spot colours are typically based on the manufacturer's specifications. Gradations of the solid value are calculated by multiplying the solid CMYK values by the tint percentage. For example, Pantone 202 U has a CMYK equivalency of 12C 88M 67Y 34K. Therefore, a 50% CMYK equivalent of the solid tint would be 6C 44M 34Y 17K. While this is not the most accurate way to convert colour data between models, it is fairly standard in graphics applications.

8.6. Spot Colour to RGB

Converting spot colour to RGB is somewhat the same as the RGB to CMYK conversions process:

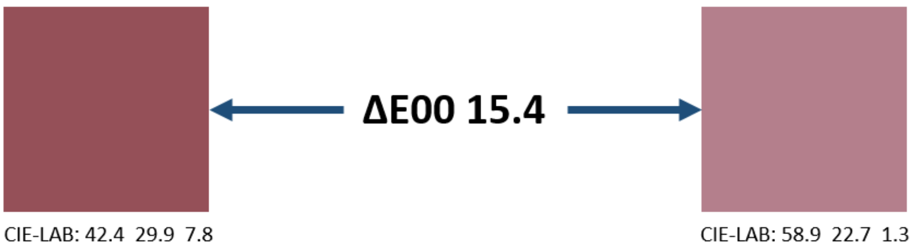
1. Convert spot colour to CIELAB using a colorimeter.
2. Convert CIELAB to XYZ.
3. Convert XYZ to RGB.

Most ink and colour manufacturers define the RGB values for their spot colours, therefore, this data is typically available. However, if an unknown spot colour is used, or one wants to translate the printed colour very precisely to a digital device, this process would be used.

8.7. Colour Difference Formula

For printing and graphics, the ∆E2000 formula is the primary way to determine the difference between two colours. As seen below, ∆E2000 determines the quantitative difference between two colours:

Figure 13: Quantitative difference between two colours determined by ∆E2000



Note the difference in CIELAB values below each of the swatches. In the earlier ∆E1976 formula, it was simply the difference between two points in three-dimensional space. However, the ∆E2000 formula accounts for high and low chroma areas, making the colour difference more accurate to how humans view and perceive colour.

9. Graphics, Printing and Mapping Terms and Applications

To de-conflict and standardize terminology between mapping and graphical/printing applications, each of the terms must be defined. The hierarchy of how visual elements interact with one another must also be delineated such that utilization in mapping and graphics applications is consistent. All of these aspects contribute to the final visualization of a product, whether that is in a digital or printed format.

All mapping and graphics elements adhere to these three basic visualization principles:

- Layering
- Opacity and Transparency
- Blending Mode
- Masking

Regardless of how a feature is portrayed or what colour an object is, if it is layered beneath another object, it will not be visible. Therefore, layering is the primary factor in visualization. Next is opacity/transparency as it impacts the extent to which an object interacts with all other objects layered beneath it. Finally is the object's blending mode, as blending modes further change the way objects layered beneath it are rendered.

9.1. Layering

Layering is the "stacking" priority of an object in relation to other objects. Objects layered above others have the ability to obscure the objects beneath it.

9.2. Opacity and Transparency

Opacity and Transparency are functions of one another. "A layer's overall opacity determines to what degree it obscures or reveals the layer beneath it. A layer with 1% opacity appears (almost) completely transparent, whereas one with 100% opacity appears completely opaque."[15] To explain further, if an object is 40% Transparent, then it is 60% Opaque. If an object is 100% Opaque, then it is not Transparent. If an object is 100% Transparent, then it has no opacity.

The effects of Transparency and Opacity are determined by the amount of transparency applied and the layering of objects. The greater the number of transparent objects that are layered on top of one another, the less the bottom layers' colours will be visible.

9.3. Blending Modes

Blending modes are the methods/algorithms by which graphics and GIS software determine how colours of vector, raster and text elements within a document interact with one another. Note that the resulting colour is often influenced by blending options in connection with layering of objects and features within a file.

9.3.1. Normal

For most objects in a file, normal blending mode is set as the default. "The resulting colour of a pixel is not affected by the colour of the underlying pixel unless Opacity is less than 100% for the source layer."[16] Objects layered above will obscure objects layered below. For example, when stacking multiple pieces of paper in a stack, the top-most piece is visible, while the pieces underneath are hidden or obscured by the top piece. Objects with a normal blending mode will behave in this fashion.

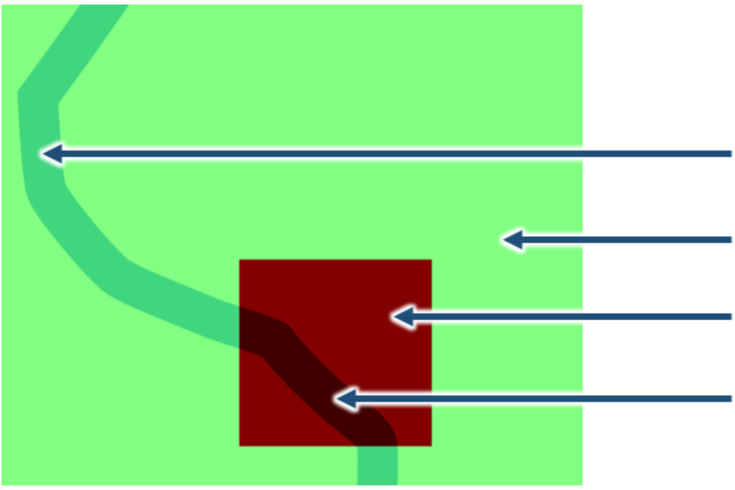
[15] https://helpx.adobe.com/photoshop/using/layer-opacity-blending.html
[16] https://helpx.adobe.com/premiere-pro/using/blending-modes.html

9.3.2. Multiply

The Multiply Blending mode, “Looks at the colour information in each channel and multiplies the base colour by the blend colour. The resulting colour is always darker. Multiplying any colour with black produces black. Multiplying any colour with white leaves the colour unchanged.”[17] “This blend mode simulates drawing with multiple marking pens on paper or placing multiple gels in front of a light.”[18]

Multiply is a blending mode in which the full values of layered objects are blended together. Figure 14 shows an example where all objects are set to multiply. Note that the red box blends with the underlying blue and green features and how that impacts the resulting blend value.

Figure 14: Multiply blending mode example



Original Value				Blended Value			
C	M	Y	K	C	M	Y	K
50	0	0	0	90	0	40	0
40	0	40	0	40	0	40	0
0	100	100	0	40	100	100	0
50	0	0	0	90	100	100	0

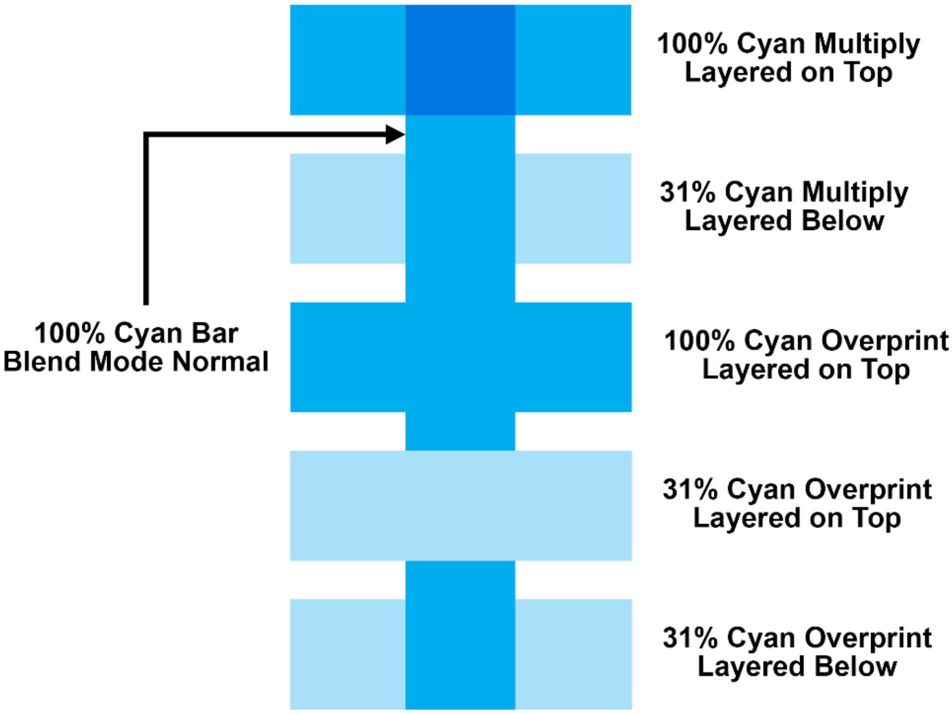
9.3.3. Overprint

In many ways, Overprint functions prefer Multiply. However, Overprint has specific parameters based on layering and colour attribution:

1. An overprinting element layered above will determine the colour percentage of all same-colour elements layered beneath it.
2. An overprinting element layered above will blend with all different-coloured elements layered beneath it (similar to Multiply).

[17] https://helpx.adobe.com/photoshop/using/blending-modes.html
[18] https://helpx.adobe.com/premiere-pro/using/blending-modes.html

Figure 15: Overprint (in connection with layering and blending mode)



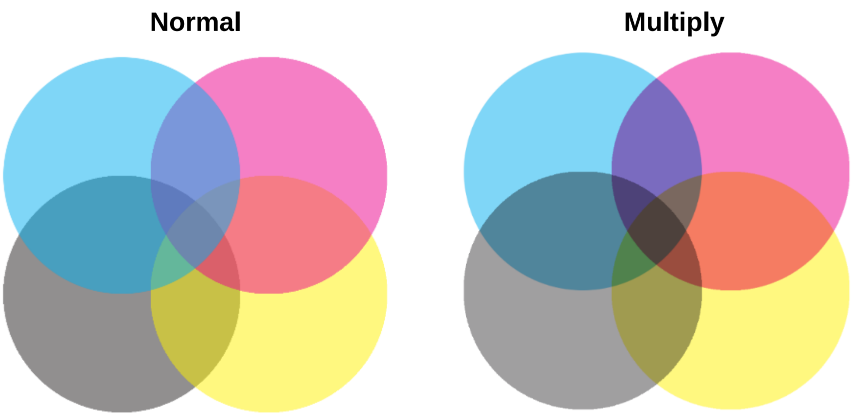
It should be noted that Overprint is more of a processing function as opposed to blending mode. While many software applications have overprint options, they are not typically utilized in the same fashion as transparency, multiply, or other blending modes.

9.3.4. Blending Modes Comparison

Normal and Multiply

Figure 16 demonstrates the main difference between normal and multiply blending modes with the same transparency (70%) and opacity (30%) values:

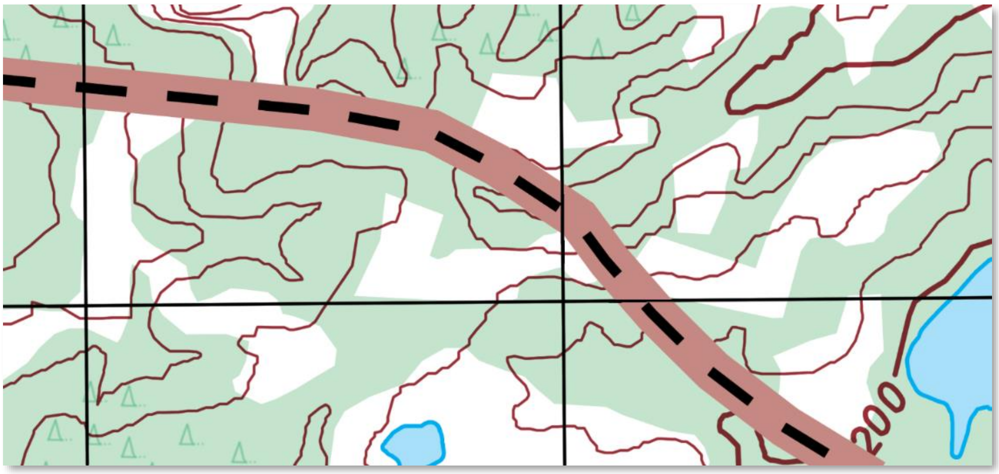
Figure 16: Normal and Multiply Blending Modes Comparison



Note that in the normal example, the grey circle has very little impact at the centre where all four circles intersect. Whereas, in the multiply example, each colour mixes equally into one another. This allows the elements layered at bottom to equally blend with the elements layered on top.

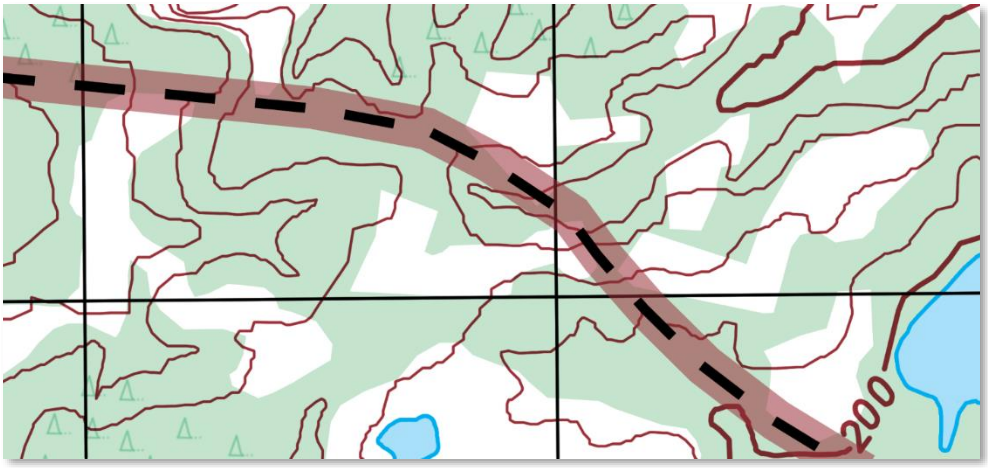
Figure 17 demonstrates the International Boundary in a TM50 utilizing Normal blending. Note that none of the features below it (such as the contours and forest) are visible.

Figure 17: International Boundary with 100% Opacity (or 0% Transparency) and normal blending



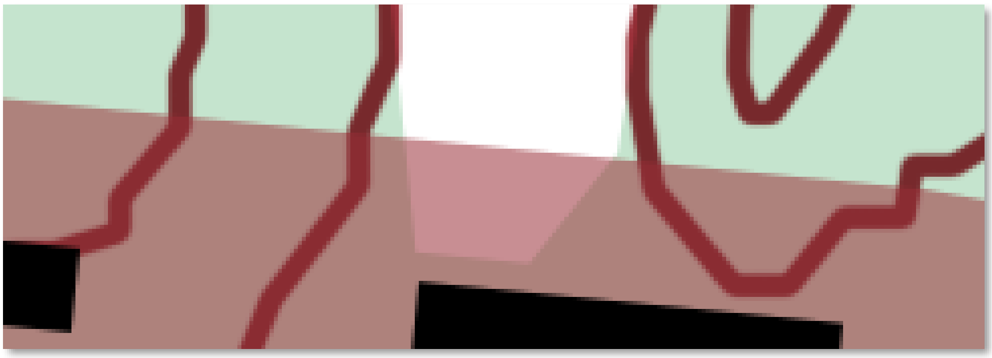
As seen in Figure 18, if the International Boundary is changed to 50% Opacity (or 50% Transparent), then features below it will be visible.

Figure 18: International Boundary with 50% Opacity (or 50% Transparency) and normal blending



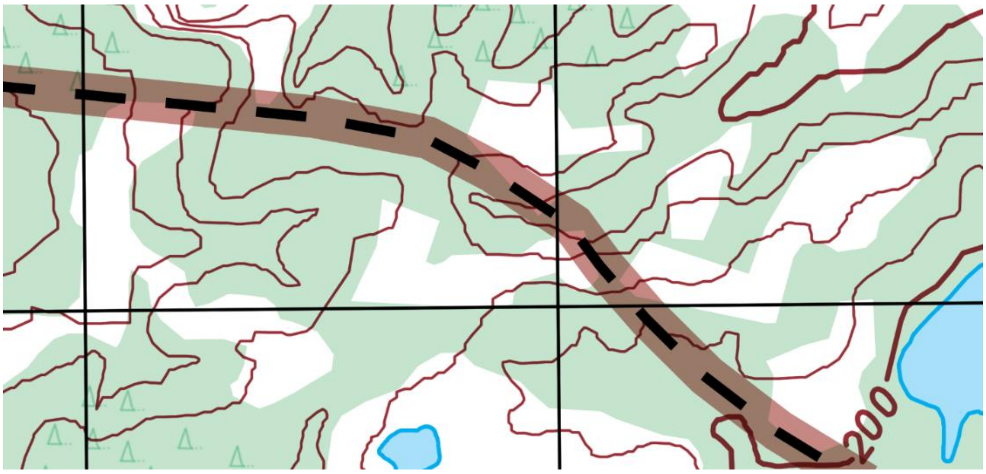
Notice in Figure 19 how the contour lines, which are 100% Dk-Brown are now slightly lighter because the transparency of the element layered on top is lighter and the blending mode is set to Normal.

Figure 19: International Boundary with 50% Opacity (or 50% Transparency) and normal blending – detail



Next, in Figure 20, the Boundary opacity is 50% and the Blending Mode has been set to Multiply:

Figure 20: International Boundary with 50% Opacity (or 50% Transparency) and multiply blending



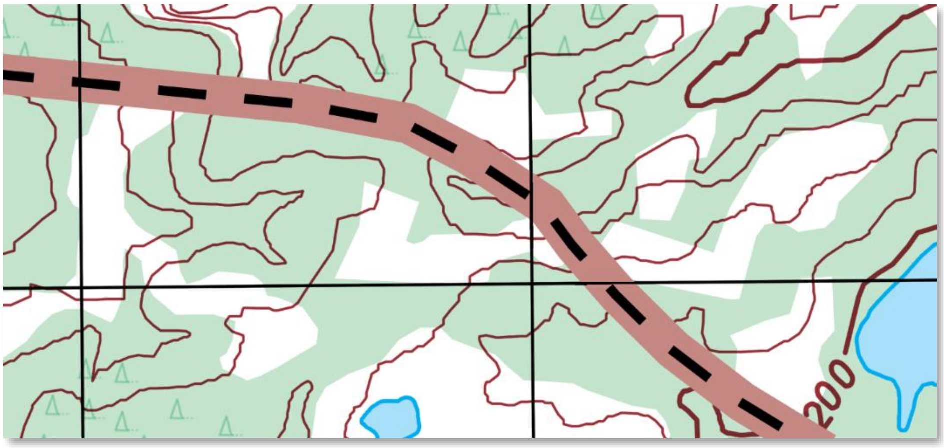
In Figure 21, with the Boundary set to Multiply, notice that the contours layered below now appear darker:

Figure 21: International Boundary with 50% Opacity (or 50% Transparency) and multiply blending – detail

Overprint and Multiply

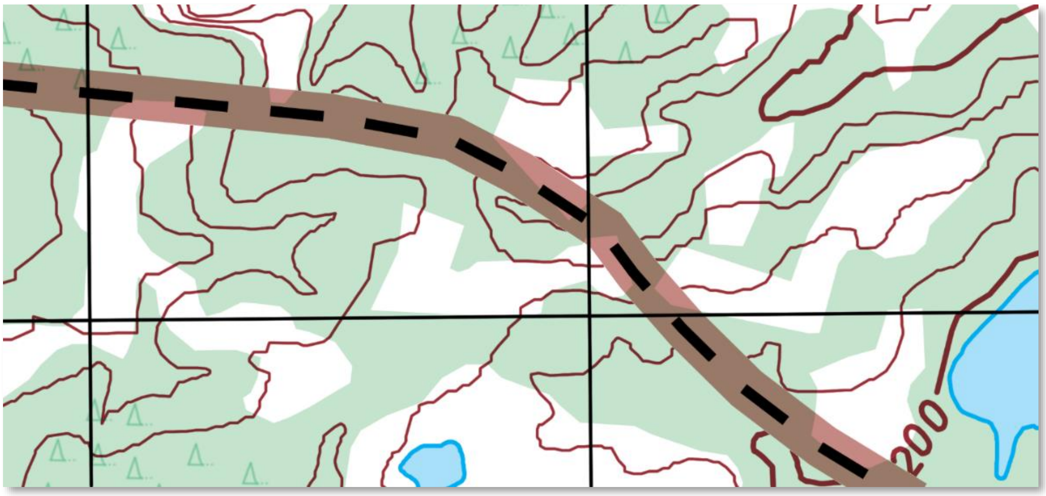
As described previously, Overprint and Multiply have many similarities. However, the key distinction is how they interact with objects of the same colour. In Figure 22, the International Boundary feature has a blending mode of "Normal".

Figure 22: International Boundary feature with normal blending mode



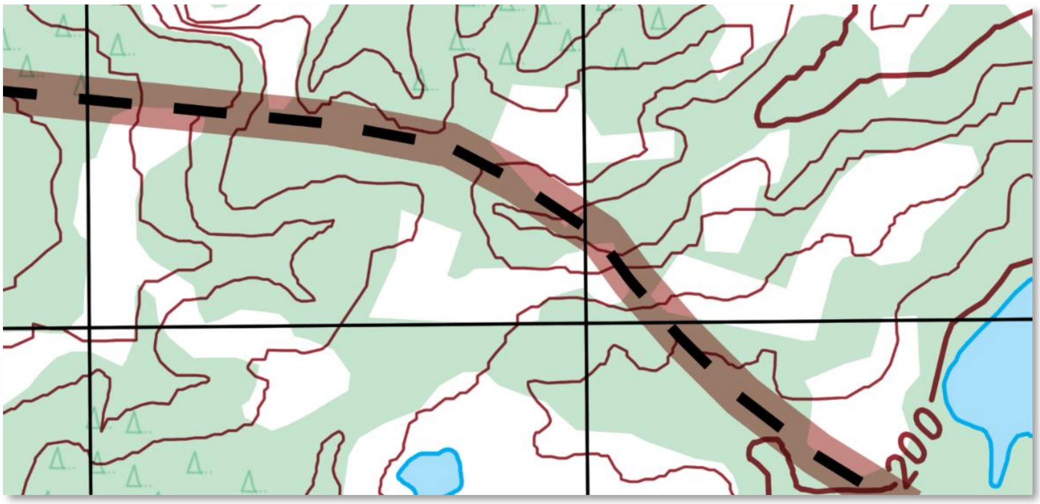
Notice that, when the Boundary feature is set to overprint (see Figure 23), the Boundary blends with the forest layered beneath it. However, the contours layered beneath the Boundary are knocked out. Just as seen in the Overprint subsection, an overprinting object layered above an object of the same colour will override the colour attribution of the object below it.

Figure 23: International Boundary feature set to overprint



Therefore, the only way to ensure that the contours are visible would be to layer them above the Boundary or to change the Boundary from blending mode to Multiply, if possible. See Figure 24.

Figure 24: International Boundary feature with multiply blending mode

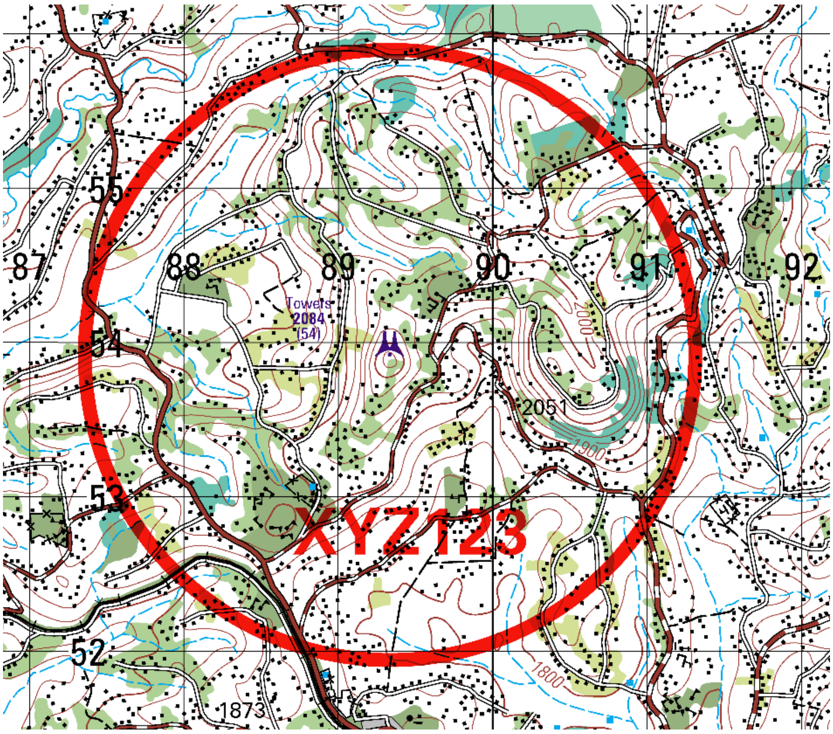


In the following example of a 1:50,000 Low Flying Chart (Figure 25), the 100% solid red colour for the airspace is shown without blending. The airspace sits ontop of all other detail.

Figure 25: Red circle without blending

In the Figure 26, the blending has been turned on giving the airspace's linework and text translucency. Note that the colour of the 100% red detail is still the same in areas where there is no underlying detail. It has not gone pink, which would be the case if the transparency of the airspace had been changed.

Figure 26: Red circle with blending



9.4. Masking

Masking is the visual hiding, obscuring or limiting of the visibility of an object or objects to make the content more legible. This is accomplished in different ways across Geographic Information Systems (GIS) and graphics software. However, the visual result is the same.

In GIS software, masking can be defined as "a technique used to clarify dense or detailed map content by having the features of one layer hide or mask features of another layer where they overlap."[19]

In GIS applications, masking can be carried out in a variety of ways:

1. Layer masking: A layer of features or a masking layer masks any overlapping features of another layer in the map or scene.
2. Feature-level masking: Masking is handled for each feature as specified by a relationship class between two layers.[20]

In graphics software, "There are two basic types of masks; layer masks and vector masks. A layer mask is pixel-based and can be created either by drawing white on a black background or by building a high contrast image (a *key*) based on the luminance or colour of the layer. A vector mask is a geometrical shape rather than a fixed image. A vector mask is adjustable, as it is not tied to individual pixels."[21] "Layer and vector masks are non-destructive, which means you can go back and re-edit the masks later without losing the pixels they hide."[22]

In graphics applications, masking can be carried out using several methods:

1. Layering an opaque object over the features that need to be hidden.
2. Performing a Boolean function to eliminate or isolate the desired object(s).

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19 https://pro.arcgis.com/en/pro-app/help/mapping/layer-properties/use-a-masking-layer.htm
20 https://pro.arcgis.com/en/pro-app/help/mapping/layer-properties/use-a-masking-layer.htm
21 https://www.techwalla.com/articles/definition-of-layer-masking-in-photoshop
22 https://helpx.adobe.com/photoshop/using/masking-layers.html

3. Creating an object that obscures or hides the desired object(s).

Because GIS software also has many similar functions to graphics software, masking can sometimes be applied in the same ways described above.

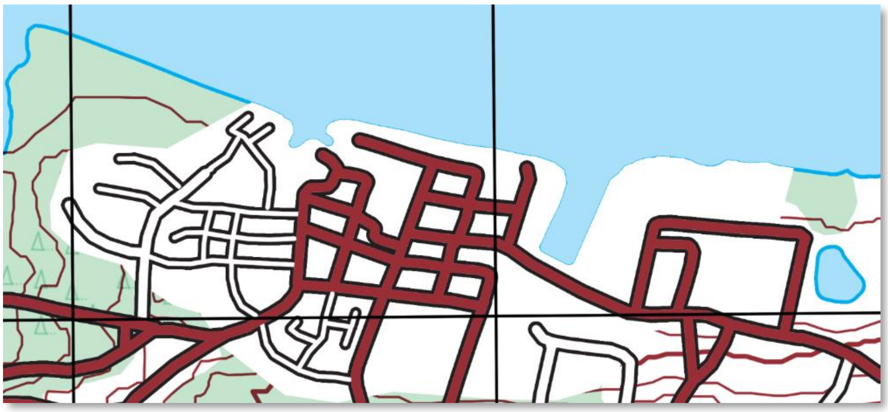
9.4.1. Masking Through Removal

This section will cover some of the different ways in which masking can be used in GIS applications. Figure 27 shows an example of a region where a Built-Up Area (BUA) will be applied.

Figure 27: Region where a Built-Up Area will be applied

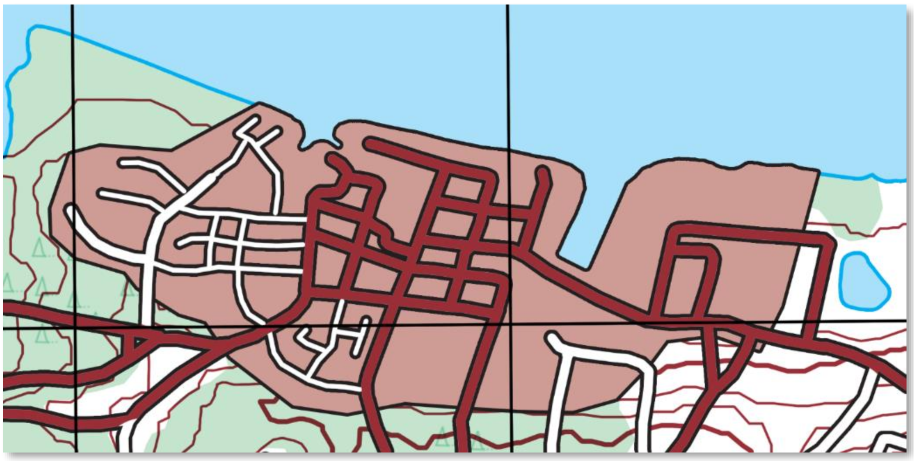
As seen in Figure 27, all of the contours and vegetation still appear in the area. However, in Figure 28, the region for the BUA has been masked out.

Figure 28: Masking out of the region for the Built-Up Area



That masking process may be part of extraction or finishing where a Boolean-type function has been applied. With the contours and vegetation masked out, the BUA can be applied, as seen in Figure 29.

Figure 29: The Built-Up Area applied with contours and vegetation masked out



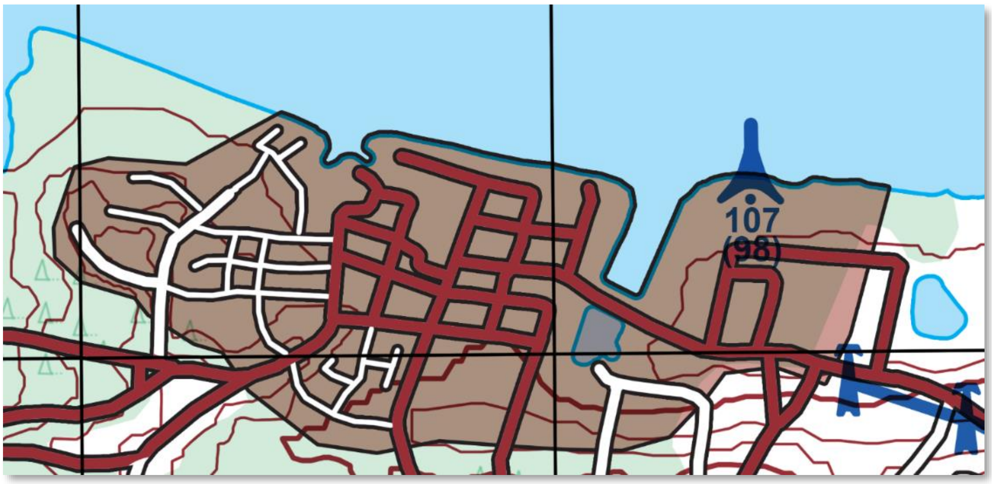
This method also aligns with the GIS methods and the Boolean graphics function described above.

9.4.2. Masking through Layering and Blending Modes

In some cases, removal of underlying features is either not possible or prudent. Therefore, the type of masking used aligns to methods used in graphics applications. As described above, the first method would be layering an opaque object over the features that need to be hidden. The result would be that all underlying visual information is still present and the visual representation would be the same as in Figure 29.

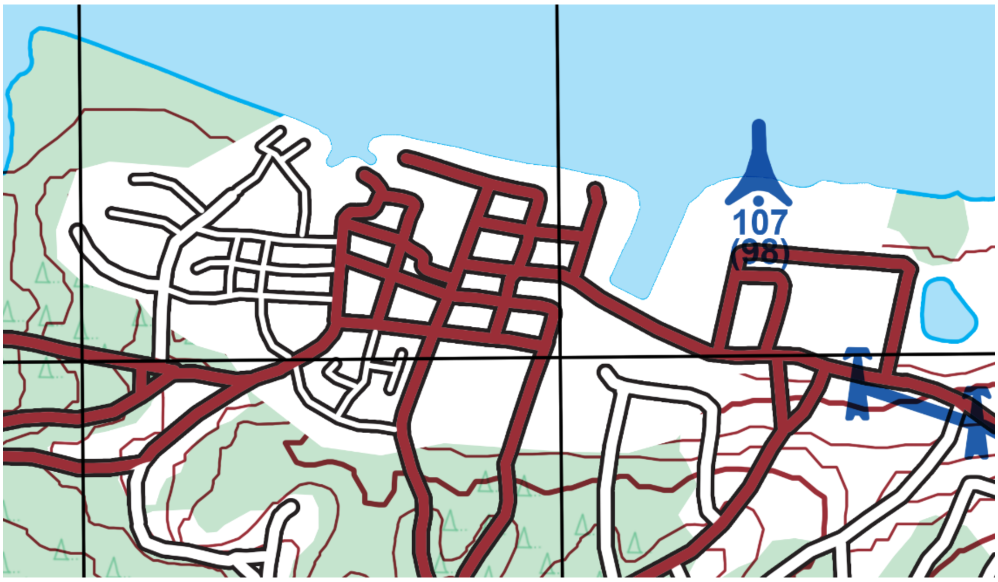
This method has some limits however. Because all the underlying data is still present, if that layer has any Transparency and/or Blending Mode (i.e. Multiply, Overprint) settings applied to it, then the underlying data will show through. In Figure 30, notice the contours and vegetation showing through the BUA.

Figure 30: Visible underlying data if Transparency and/or Blending Mode applied



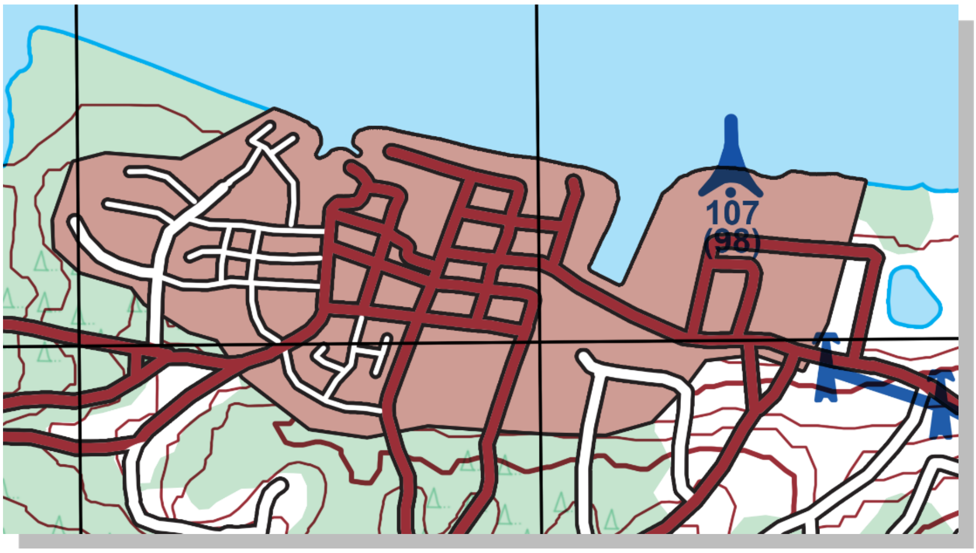
Therefore, to mitigate this problem, the third option of graphical-type masking would be to create an object that obscures or hides the desired object(s). Typically, this is done by duplicating the masking object (the BUA in this case), layering it underneath the desired feature and making it opaque white, as in Figure 31.

Figure 31: Opaque white object (the Built-Up Area) obscuring or hiding the desired objects



So, even if the BUA feature were to have Transparency and Blending Mode (i.e. Multiply, Overprint) applied to it, it would still look like Figure 32.

Figure 32: The Built-Up Area hiding contours and vegetation even if Transparency and Blending Mode is applied



The limiting factor of this method is that it adds more objects, vectors, etc. into the final output which can increase file size and rendering times. Each method has benefits and shortcomings so one must always keep in mind all aspects of layering, transparency and blending modes to ensure that the end product meets all required specifications and desired visualization.

10. Historical comparison of DPS and Graphics Terms

Over the years, mapping and printing definitions have become somewhat blurred. A good example of this is the term “Overprint”. In mapping, this has become almost synonymous with “overlap”. However, in printing, “Overprint” has a very specific meaning. The sections below will describe these terms and what they mean in the context of both mapping and printing.

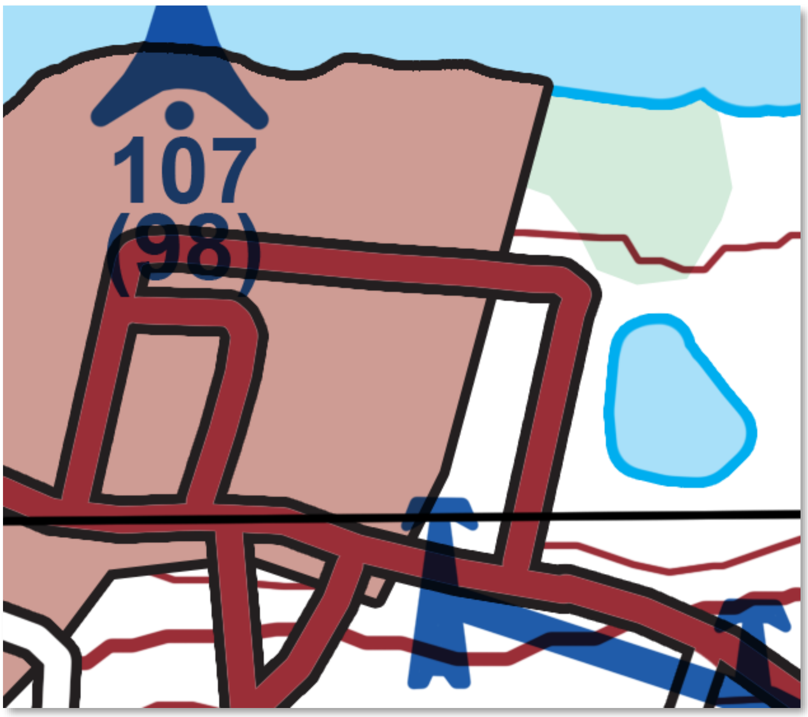
10.1. Overprint

Product finishing rules in DGIF/NGIF DPSs use the term “Overprint” to highlight labels and feature symbols that overlap, causing legibility problems. Figure 33 shows what the DPS considers overprinting to be.

Figure 33: Overprint as considered in DPS

According to graphics and printing definitions, Figure 34 shows an example of overprinting, where two or more colours mix together based on their blending mode:

Figure 34: Overprint as considered in graphics



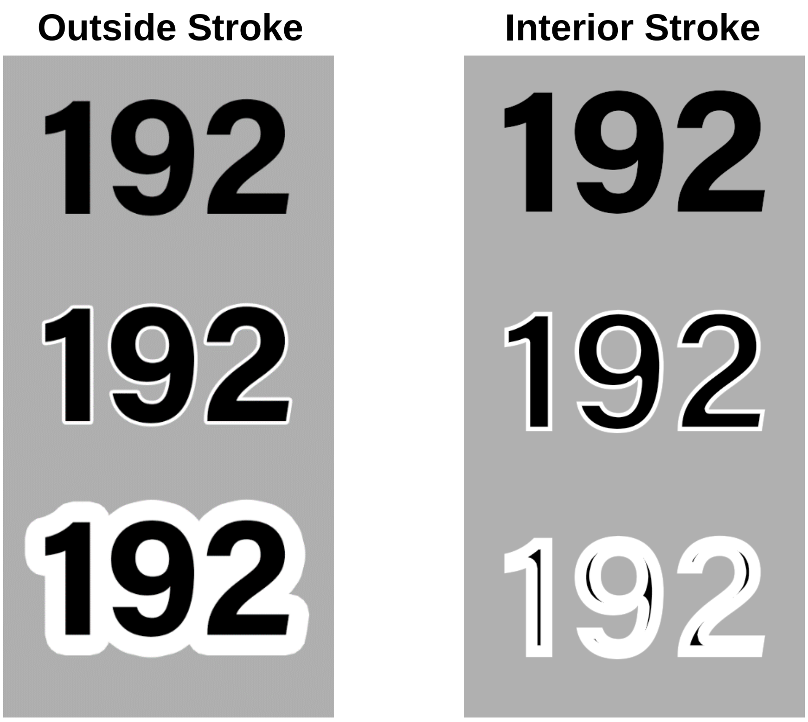
10.2. Stroke and Halo

Strokes and halos are broadly similar. However, the term “Stroke” comprises the entirety of a particular graphical function whilst “Halo” is a subset. The section below will explain the differences.

Stroke

A stroke is a visual element that encompasses the perimeter of an object and is a particular colour, width and opacity. Also, it may be applied to raster, vector and text elements. A stroke is typically assigned to extend outside, or into the interior of the object. In Figure 35, the top number has no stroke, the middle number has a small, white stroke and the bottom number has a larger, white stroke.

Figure 35: Application of stroke



Halo

As has become common in GIS software, an outside stroke has become known as a “halo”. They are commonly applied to text labels and can also be used to mask out certain underlying features. As stated above, a halo is a specific subset of stroke.

11. Colours and Colour Profiles

11.1. Pantone Colour System

The recommended colour system is Pantone Matching System, usually referred to as Pantone, whose colour definitions are available at https://www.pantone.com/color-systems/for-graphic-design. This is a proprietary colour system from Pantone LLC[23] and the current printing industry standard. Legacy SPC ink codes may be present in DPS or older MIL-SPEC documents. However, these should not be referred to as the authoritative name for any ink colour used for printing reproduction. See Annex A for Pantone Colour System and its equivalency to other colour models.

11.2. FOGRA39 ICC Profile for Map Printing

In order for colour to be accurately rendered and printed, a common International Color Consortium (ICC) Colour Profile must be used by all map and chart producers and printers.

An ICC profile is a set of data that characterizes a colour input or output device, or a colour space, according to standards promulgated by the ICC. Profiles describe the colour attributes of a particular device or viewing requirement by defining a mapping between the device source or target colour space and a profile connection space (PCS). This PCS is either CIELAB (L*a*b*) or CIEXYZ. Mappings may be specified using tables to which interpolation is applied, or alternatively, through a series of parameters for transformations.

FOGRA39, 300% Total Accumulated Colour (TAC) colour profile is the recommended ICC Colour Profile for maps and charts. It has provided consistent results for NATO. Later versions of the FOGRA profile are now available such as FOGRA42 and these may further enhance the depiction of colour.

11.3. Naming Convention for Colours

In order to identify a colour unambiguously, a normative naming convention shall be used within DGIWG and NATO artefacts. Besides colour values specification, Annex A contains the following authoritative names which shall be applied for colour identification within the defence environment:

- *Pantone Colour* – as an official technical colour identification within the Pantone Colour System.
- *Common Name* – which can serve as a human readable colour identification.
- *Colour Token Name* – which concatenates Common Name, simplified Pantone Colour and percentage of screening.

[23] limited liability company

Annex A

(normative)

Colour Specification Guide and Equivalency Table

This Annex is a mandatory part of the standard. The information contained herein is intended for compliance.

The **RGB values** in the below table were derived from the CIE-LAB values using the sRGB ICC profile.

The **CMYK values** in the below table were derived from the Pantone Uncoated Library's spot colour to CMYK equivalency.

The **CIE-LAB values** in the below table were catalogued using an X-rite I1 Pro spectrophotometer utilizing D50 as the standard illuminant setting.

The **Maximum Acceptable ΔE00 values** in the below table account for variations in paper, inks (both digital and press), and minor environmental differences. The ΔE00 for press is lower than digital due to the fact that the colour specifications are derived from Pantone Spot Colours, which are a press-based ink set. Also, the ΔE00 for 46351 (i.e. Aero Blue or Pantone Blue 072 U) is set higher due to the fact that emulating all gradations of rich, vibrant colours – on uncoated or matte paper – extends beyond the typical gamut for most digital printers.

NAVPLAN shall refer to the following products when listed in the Product Lines field of the Annex A tables: Joint Operations Graphic – JOG, Tactical Pilotage Chart – TPC, Operational Navigation Chart – ONC, Jet Navigation Chart – JNC and Global Navigation Chart – GNC.

Pantone Colour	NGA SPC Number	Product Lines	Common Name	Description	Colour Token Name	Low-Light Readability			Color Swatches	Screen %	RGB Equivalent Values			Hexidecimal Values	CMYK Equivalent Values				CIE-LAB Values			Maximum Acceptable ΔE00	
						Red	Green	Blue			R	G	B		C	M	Y	K	L	A	B	Press	Digital
Reflex Blue U	46250	LFC Training Area	Reflex Blue	Assigned to features such as Controlled Airspace, Aerodromes, Max Elevation Features, and Caution Notes.	Reflex-Blue	Yes	Yes	Yes		100%	55	74	156	#374A9C	100	74	5	5	34,0	14,0	-48,0	4,0	8,0
					Reflex-Blue-91					91%	73	90	165	#495AA5	100	71	2	1	40,0	11,0	-43,0		
					Reflex-Blue-79					79%	97	112	177	#6170B1	84	58	1	0	48,0	8,0	-37,0		
					Reflex-Blue-67					67%	121	134	189	#7986BD	66	46	3	0	57,0	5,0	-31,0		
					Reflex-Blue-54					54%	147	157	201	#939DC9	49	35	4	0	65,0	4,0	-24,0		
					Reflex-Blue-42					42%	171	179	213	#ABB3D5	37	26	5	0	73,0	2,0	-18,0		
					Reflex-Blue-31					31%	193	199	224	#C1C7E0	26	19	4	0	80,0	2,0	-13,0		
					Reflex-Blue-21					21%	213	217	234	#D5D9EA	17	13	3	0	87,0	1,0	-9,0		
					Reflex-Blue-12					12%	231	233	243	#E7E9F3	10	7	2	0	92,0	1,0	-5,0		
					Reflex-Blue-07					7%	241	242	248	#F1F2F8	6	4	1	0	96,0	0,0	-3,0		
Blue 072 U	46351	DTM LPC MDG NAVPLAN SNC TLM TM	Aero Blue	Assigned to features such as Vertical Obstructions, Runways, Aerodromes, etc.	Aero-Blue072	Yes	Yes	Yes		100%	56	70	157	#38469D	92	70	0	0	33,4	22,5	-48,7	4,0	8,0
					Aero-Blue072-91					91%	54	72	160	#3648A0	84	64	0	0	33,9	22,6	-50,1		
					Aero-Blue072-79					79%	67	83	167	#4353A7	73	55	0	0	38,2	20,1	-47,3		
					Aero-Blue072-67					67%	74	94	177	#4A5EB1	62	47	0	0	42,1	18,2	-46,8		
					Aero-Blue072-54					54%	97	113	187	#6171BB	50	38	0	0	49,5	14,3	-40,8		
					Aero-Blue072-42					42%	121	135	200	#7987C8	39	29	0	0	57,5	11,2	-35,3		
					Aero-Blue072-31					31%	140	153	209	#8C99D1	29	22	0	0	64,1	8,8	-30,2		
					Aero-Blue072-21					21%	165	175	220	#A5AFDC	19	15	0	0	72,0	6,4	-24,1		
					Aero-Blue072-12					12%	192	199	233	#C0C7E9	11	8	0	0	80,8	4,4	-17,3		
					Aero-Blue072-07					7%	208	213	240	#D0D5F0	6	5	0	0	85,6	3,4	-13,7		
7462 U	46961	DTM MDG MIM NAVPLAN TLM TM	Blue Light Readable Blue	Typically replaces 48253 (Cyan) for drainage/water features on products requiring Blue/Green Light Readability.	Blue-Light-Readable-Blue7462	Yes	Yes	Yes		100%	80	118	152	#507698	78	32	10	11	48,1	-3,3	-22,7	4,0	5,0
					Blue-Light-Readable-Blue7462-91					91%	86	123	158	#567B9E	71	29	9	10	50,3	-3,4	-22,7		
					Blue-Light-Readable-Blue7462-79					79%	94	132	167	#5E84A7	62	25	8	9	53,7	-3,8	-22,7		
					Blue-Light-Readable-Blue7462-67					67%	102	140	175	#668CAF	52	21	7	7	56,9	-3,9	-22,6		
					Blue-Light-Readable-Blue7462-54					54%	114	151	185	#7297B9	42	17	5	6	61,1	-4	-21,8		
					Blue-Light-Readable-Blue7462-42					42%	130	165	198	#82A5C6	33	13	4	5	66,2	-3,8	-20,7		
					Blue-Light-Readable-Blue7462-31					31%	149	179	210	#95B3D2	24	10	3	3	71,8	-3,2	-19,1		
					Blue-Light-Readable-Blue7462-21					21%	174	198	225	#AEC6E1	16	7	2	2	78,8	-2,1	-16,1		
					Blue-Light-Readable-Blue7462-12					12%	201	216	237	#C9D8ED	9	4	1	1	85,8	-0,8	-12		
					Blue-Light-Readable-Blue7462-07					7%	215	225	243	#D7E1F3	5	2	1	1	89,2	0,2	-10,1		
285 U	47651	BNPC NAVPLAN TLM	Legacy Blue	Legacy color used in TLM products for drainage/water features.	Legacy-Blue285	Yes	No	No		100%	60	152	220	#3C98DC	70	30	0	0	60,3	-4,8	-42,3	4,0	5,0
					Legacy-Blue285-91					91%	68	155	221	#449BDD	64	27	0	0	61,5	-4,9	-41,2		
					Legacy-Blue285-79					79%	86	163	224	#56A3E0	55	24	0	0	64,5	-5,1	-38,3		
					Legacy-Blue285-67					67%	102	169	227	#66A9E3	47	20	0	0	67,1	-4,9	-35,5		
					Legacy-Blue285-54					54%	125	180	231	#7DB4E7	38	16	0	0	71,4	-4,4	-31,3		
					Legacy-Blue285-42					42%	148	192	236	#94C0EC	29	13	0	0	76,2	-4,0	-26,4		
					Legacy-Blue285-31					31%	168	202	239	#A8CAEF	22	9	0	0	80,2	-3,0	-21,9		
					Legacy-Blue285-21					21%	188	213	242	#BCD5F2	15	6	0	0	84,2	-2,1	-17,0		
					Legacy-Blue285-12					12%	208	223	245	#D0DFF5	8	4	0	0	88,4	-0,9	-12,4		
					Legacy-Blue285-07					7%	219	230	248	#DBE6F8	5	2	0	0	90,9	-0,1	-10,0		

Pantone Colour	NGA SPC Number	Product Lines	Common Name	Description	Colour Token Name	Low-Light Readability			Color Swatches	Screen %	RGB Equivalent Values			Hexidecimal Values	CMYK Equivalent Values				CIE-LAB Values			Maximum Acceptable ΔE00	
						Red	Green	Blue			R	G	B		C	M	Y	K	L	A	B	Press	Digital
Process Cyan U	48253	BNPC City Graphic DTM EVC HITS ICM LPC MDG NAVPLAN OPAREA SNC	Cyan	Used for drainage/water features in topographic and aeronautical products. Used for near-shore tints in hydrographic products.	Cyan	Yes	No	No		100%	0	160	223	#01A0DF	100	0	0	0	59,5	-26,0	-45,6	4,0	5,0
					Cyan-91					91%	0	163	224	#01A3E0	91	0	0	0	61,1	-25,3	-43,5		
					Cyan-79					79%	0	174	228	#01AEE4	79	0	0	0	65,8	-21,4	-38,5		
					Cyan-67					67%	30	180	231	#1EB4E7	67	0	0	0	68,7	-19,5	-35,4		
					Cyan-54					54%	89	190	234	#59BEEA	54	0	0	0	72,9	-16,7	-30,4		
					Cyan-42					42%	132	202	238	#84CAEE	42	0	0	0	78,0	-12,4	-24,9		
					Cyan-31					31%	158	210	241	#9ED2F1	31	0	0	0	81,7	-9,3	-20,6		
					Cyan-21					21%	187	221	244	#BBDDF4	21	0	0	0	86,3	-6,0	-15,1		
					Cyan-12					12%	206	228	246	#CEE4F6	12	0	0	0	89,4	-3,4	-11,5		
					Cyan-07					7%	217	232	247	#D9E8F7	7	0	0	0	91,3	-1,9	-8,9		
3258 U	49733	BNPC OPAREA SNC	Hydro Green	Common name: "Hydro Green." Typically used for sector lights, buoys, drag zones, etc. in hydrographic products.	Hydro-Green3258	Yes	No	No		100%	71	188	174	#47BCAE	55	0	33	0	69,8	-36,0	-2,6	4,0	5,0
					Hydro-Green3258-91					91%	80	191	178	#50BFB2	50	0	30	0	71,0	-34,6	-2,9		
					Hydro-Green3258-79					79%	93	194	182	#5DC2B6	43	0	26	0	72,5	-32,2	-3,1		
					Hydro-Green3258-67					67%	106	200	190	#6AC8BE	37	0	22	0	74,8	-30,2	-3,6		
					Hydro-Green3258-54					54%	128	206	199	#80CEC7	30	0	18	0	77,8	-25,5	-4,2		
					Hydro-Green3258-42					42%	144	211	207	#90D3CF	23	0	14	0	80,3	-22,2	-4,5		
					Hydro-Green3258-31					31%	167	218	217	#A7DAD9	17	0	10	0	83,7	-16,7	-4,7		
					Hydro-Green3258-21					21%	188	224	226	#BCE0E2	12	0	7	0	86,8	-11,6	-4,7		
					Hydro-Green3258-12					12%	207	230	235	#CFE6EB	7	0	4	0	89,8	-6,8	-5,0		
					Hydro-Green3258-07					7%	219	234	241	#DBEAF1	4	0	2	0	91,9	-3,6	-5,1		
354 U	N/A	DoD FLIP Enroute Charts	Enroute Chart Green	Used for features like operating area boundaries.	Enroute-Chart-Green354	Yes	Yes	Yes		100%	0	169	92	#308167	82	5	88	0	59,0	-60,0	26,0	4,0	5,0
					Enroute-Chart-Green354-67					67%	80	184	144	#50B990	55	3	59	0	69,0	-37,0	12,0		
					Enroute-Chart-Green354-42					42%	140	206	184	#8CCDB8	34	2	37	0	79,0	-22,0	6,0		
					Enroute-Chart-Green354-21					21%	191	223	218	#BFDFDA	17	1	18	0	87,0	-10,0	1,0		
355 U	51022	DTM MDG MIM NAVPLAN TLM TM	Green Light Readable Green	Typically replaces 52813 (Topo Green) for maps requiring Blue/Green Light Readability. Used for vegetation features in topographic maps. Used for vegetation and zoning features in MIMs.	Green-Light-Readable-Green355	Yes	Yes	Yes		100%	3	152	89	#039859	82	0	92	0	55,2	-49,0	23,6	4,0	5,0
					Green-Light-Readable-Green355-91					91%	35	155	96	#239B60	75	0	84	0	56,6	-46,1	22,0		
					Green-Light-Readable-Green355-79					79%	41	159	100	#299F64	65	0	73	0	58,2	-46,1	22,0		
					Green-Light-Readable-Green355-67					67%	52	165	106	#34A56A	55	0	62	0	60,6	-45,5	21,7		
					Green-Light-Readable-Green355-54					54%	77	178	122	#4DB27A	44	0	50	0	65,6	-42,6	20,1		
					Green-Light-Readable-Green355-42					42%	104	189	141	#68BD8D	34	0	39	0	70,5	-37,0	16,8		
					Green-Light-Readable-Green355-31					31%	134	201	163	#86C9A3	25	0	29	0	75,8	-29,4	12,4		
					Green-Light-Readable-Green355-21					21%	161	211	185	#A1D3B9	17	0	19	0	80,6	-21,8	7,9		
					Green-Light-Readable-Green355-12					12%	189	223	209	#BDDFD1	10	0	11	0	86,1	-13,8	3,3		
					Green-Light-Readable-Green355-7					7%	203	229	220	#CBE5DC	6	0	6	0	88,8	-10,0	1,2		

Pantone Colour	NGA SPC Number	Product Lines	Common Name	Description	Colour Token Name	Low-Light Readability			Color Swatches	Screen %	RGB Equivalent Values			Hexidecimal Values	CMYK Equivalent Values				CIE-LAB Values			Maximum Acceptable ΔE00	
						Red	Green	Blue			R	G	B		C	M	Y	K	L	A	B	Press	Digital
3415 U	51411	NAVPLAN	Aero Green	Typically used for isogonic lines and other reference features.	Aero-Green3415	Yes	TBD	TBD		100%	48	129	103	#308167	81	29	67	11	46,0	-31,0	5,0	4,0	5,0
					Aero-Green3415-91					91%	53	126	111	#357E6F	74	26	61	10	48,0	-25,0	0,0		
					Aero-Green3415-79					79%	78	141	130	#4E8E82	64	23	53	9	55,0	-22,0	-1,0		
					Aero-Green3415-67					67%	103	156	148	#679C94	54	19	45	7	60,0	-18,0	-2,0		
					Aero-Green3415-54					54%	130	173	168	#81ACA8	44	16	36	6	67,0	-14,0	-2,0		
					Aero-Green3415-42					42%	155	188	186	#9BBCBA	34	12	28	5	74,0	-11,0	-3,0		
					Aero-Green3415-31					31%	178	201	203	#B2CACD	25	9	21	3	79,0	-7,0	-3,0		
					Aero-Green3415-21					21%	198	214	219	#C6D6DA	17	6	14	2	84,0	-4,0	-4,0		
					Aero-Green3415-12					12%	217	226	233	#D9E1E8	10	3	8	1	89,0	-2,0	-4,0		
					Aero-Green3415-07					7%	227	232	240	#E3E7F0	6	2	5	1	92,0	0,0	-5,0		
346 U	52813	DTM LPC MDG NAVPLAN TLM TM	Topo Green	Used for vegetation features in topographic maps and littoral charts.	Topo-Green346	Yes	No	No		100%	23	158	106	#179E6A	55	0	51	0	57,8	-46,5	17,6	4,0	5,0
					Topo-Green346-91					91%	23	161	109	#17A16D	50	0	46	0	58,9	-47,2	17,9		
					Topo-Green346-79					79%	53	167	118	#35A776	43	0	40	0	61,5	-43,6	16,4		
					Topo-Green346-67					67%	76	177	131	#4CB183	37	0	34	0	65,5	-40,6	14,9		
					Topo-Green346-54					54%	101	183	144	#65B790	30	0	28	0	68,6	-34,2	12,1		
					Topo-Green346-42					42%	131	194	164	#83C2A4	23	0	21	0	73,7	-27,0	8,9		
					Topo-Green346-31					31%	154	205	181	#9ACDB5	17	0	16	0	78,3	-21,2	6,3		
					Topo-Green346-21					21%	176	214	199	#B0D6C7	12	0	11	0	82,5	-15,2	3,2		
					Topo-Green346-12					12%	200	224	217	#C8E0D9	7	0	6	0	87,2	-9,2	0,4		
					Topo-Green346-07					7%	212	229	227	#D4E5E3	4	0	4	0	89,6	-5,8	-0,9		
Process Yellow U	57377	EVC ICM LPC MIM NAVPLAN SNC	Yellow	Used for numbered features in ICMs, hypsometric tints in JOGA/NAVPLAN products, sector lights in SNCs, grid numbers in MIMs, and land tint in LPCs.	Yellow	No	No	Yes		100%	255	221	22	#FFDD16	0	0	100	0	88,9	-2,9	86,6	4,0	5,0
					Yellow-91					91%	255	220	48	#FFDC30	0	0	91	0	88,6	-2,8	81,1		
					Yellow-79					79%	255	224	74	#FFE04A	0	0	79	0	89,8	-3,5	74,0		
					Yellow-67					67%	255	225	91	#FFE15B	0	0	67	0	90,0	-3,8	67,5		
					Yellow-54					54%	255	228	122	#FFE47A	0	0	54	0	90,7	-3,7	54,6		
					Yellow-42					42%	253	230	145	#FDE691	0	0	42	0	91,4	-3,4	44,1		
					Yellow-31					31%	248	230	168	#F8E6A8	0	0	31	0	91,5	-2,8	32,8		
					Yellow-21					21%	247	234	194	#F7EAC2	0	0	21	0	92,9	-1,9	21,3		
					Yellow-12					12%	245	236	214	#F5ECD6	0	0	12	0	93,6	-0,8	11,6		
					Yellow-07					7%	243	237	226	#F3EDE2	0	0	7	0	94,0	-0,1	6,0		
7504 U	58422	BNPC HITS MIM OPAREA	Brown	Used for boundaries and Aviation Routes in MIMs.	Brown7504	Yes	Yes	Yes		100%	159	136	123	#9F887B	15	27	46	37	58,5	6,3	10,4	4,0	5,0
					Brown7504-91					91%	163	141	128	#A38D80	14	25	42	34	60,3	6,2	10,3		
					Brown7504-79					79%	161	141	129	#A18D81	12	21	36	29	60,0	5,8	9,2		
					Brown7504-67					67%	171	151	140	#AB978C	10	18	31	25	63,9	5,6	8,6		
					Brown7504-54					54%	180	163	154	#B4A39A	8	15	25	20	68,1	5,0	6,7		
					Brown7504-42					42%	191	177	171	#BFB1AB	6	11	19	16	73,2	4,3	4,6		
					Brown7504-31					31%	201	190	187	#C9BEBB	5	8	14	11	77,7	3,7	2,9		
					Brown7504-21					21%	212	204	204	#D4CCCC	3	6	10	8	82,6	3,1	0,8		
					Brown7504-12					12%	220	214	217	#DCD6D9	2	3	6	4	86,3	2,6	-0,7		
					Brown7504-07					7%	227	222	226	#E3DEE2	1	2	3	3	89,0	2,2	-1,5		

Pantone Colour	NGA SPC Number	Product Lines	Common Name	Description	Colour Token Name	Low-Light Readability			Color Swatches	Screen %	RGB Equivalent Values			Hexidecimal Values	CMYK Equivalent Values				CIE-LAB Values			Maximum Acceptable ΔE00	
						Red	Green	Blue			R	G	B		C	M	Y	K	L	A	B	Press	Digital
Process Black U	58600	BNPC City Graphic DTM EVC HITS ICM LPC MDG MIM NAVPLAN	Black	Typically used for text, grids, and culture features in all products lines.	Black	Yes	Yes	Yes		100%	75	75	75	#4B4B4B	0	0	0	100	31,9	1,6	1,5	4,0	5,0
					Black-91					91%	92	92	92	#5C5C5C	0	0	0	91	39,1	1,4	0,5		
					Black-79					79%	100	100	100	#646464	0	0	0	79	42,5	1,2	-0,2		
					Black-67					67%	121	121	121	#797979	0	0	0	67	50,8	1,1	-1,2		
					Black-54					54%	139	139	139	#8B8B8B	0	0	0	54	57,7	1,1	-1,7		
					Black-42					42%	158	158	158	#9E9E9E	0	0	0	42	64,6	1,1	-2,2		
					Black-31					31%	174	174	174	#AEAEAE	0	0	0	31	70,7	1,1	-2,9		
					Black-21					21%	194	194	194	#C2C2C2	0	0	0	21	77,5	1,2	-3,7		
					Black-12					12%	211	211	211	#D3D3D3	0	0	0	12	83,8	1,4	-4,2		
					Black-07					7%	224	224	224	#E0E0E0	0	0	0	7	87,8	1,5	-4,3		
7413 U	59062	City Graphic MIM	Yellow-Brown	Typically used for culture features in City Graphics and Aviation Routes in MIMs.	Yellow-Brown7413	No	Yes	Yes		100%	225	154	102	#E19A66	0	44	81	2	69,6	21,2	37,7	4,0	5,0
					Yellow-Brown7413-91					91%	227	157	107	#E39D6B	0	40	74	2	70,5	20,4	36,6		
					Yellow-Brown7413-79					79%	228	164	119	#E4A477	0	35	64	2	72,6	18,3	32,8		
					Yellow-Brown7413-67					67%	229	171	129	#E5AB81	0	29	54	1	74,4	16,4	29,7		
					Yellow-Brown7413-54					54%	231	179	142	#E7B38E	0	24	44	1	76,8	14,4	26,4		
					Yellow-Brown7413-42					42%	234	188	157	#EABC9D	0	18	34	1	79,6	12,0	22,0		
					Yellow-Brown7413-31					31%	235	199	176	#EBC7B0	0	14	25	1	82,7	9,3	16,5		
					Yellow-Brown7413-21					21%	236	208	191	#ECD0BF	0	9	17	0	85,5	7,1	12,1		
					Yellow-Brown7413-12					12%	237	219	210	#EDDBD2	0	5	10	0	88,6	4,8	6,6		
					Yellow-Brown7413-07					7%	238	226	222	#EEE2DE	0	3	6	0	90,8	3,1	3,5		
1655 U	60853	LFC Training Area	Orange	Typically used for Aeronautical features such as Vertical Obstructions, Caution Notes, Danger or Restricted Areas, Sites, and Ranges.	Orange1655	No	Yes	Yes		100%	255	112	75	#FF704B	0	63	73	0	67,0	58,0	51,0	4,0	5,0
					Orange1655-91					91%	255	125	75	#FF7D4B	0	57	78	0	68,0	48,0	51,0		
					Orange1655-79					79%	255	142	113	#FF8E71	0	51	53	0	71,0	42,0	35,0		
					Orange1655-67					67%	255	159	134	#FF9F86	0	44	43	0	75,0	35,0	29,0		
					Orange1655-54					54%	255	178	158	#FFB29E	0	36	32	0	80,0	27,0	22,0		
					Orange1655-42					42%	255	195	178	#FFC3B2	0	28	24	0	84,0	20,0	17,0		
					Orange1655-31					31%	255	211	199	#FFD3C7	0	21	17	0	88,0	15,0	12,0		
					Orange1655-21					21%	255	225	217	#FFE1D9	0	15	11	0	92,0	10,0	8,0		
					Orange1655-12					12%	255	238	233	#FFEEE9	0	9	6	0	95,0	5,0	5,0		
					Orange1655-07					7%	255	245	242	#FFF5F2	0	5	4	0	97,0	3,0	3,0		
Red 032 U	60862	City Graphic MIM LFC Training Area	Red	Typically used for numbered features in City Graphics and Aviation Routes in MIMs. Also used for Aeronautical features such as Vertical Obstructions, Caution Notes, Danger or Restricted Areas, Sites, and Ranges.	Red032	No	Yes	Yes		100%	246	80	88	#F65058	0	79	60	0	60,0	66,0	35,0	4,0	5,0
					Red032-91					91%	252	97	103	#FC6167	0	72	51	30	63,0	60,0	30,0		
					Red032-79					79%	253	118	123	#FD767B	0	63	40	0	67,0	53,0	24,0		
					Red032-67					67%	253	138	143	#FD8A8F	0	55	31	0	71,0	45,0	18,0		
					Red032-54					54%	254	161	165	#FDA1A5	0	44	23	0	76,0	35,0	13,0		
					Red032-42					42%	254	182	185	#FEB6B9	0	35	17	0	81,0	27,0	0,0		
					Red032-31					31%	254	201	203	#FEC9CB	0	26	12	0	86,0	20,0	7,0		
					Red032-21					21%	255	218	220	#FEDADC	0	18	8	0	90,0	13,0	4,0		
					Red032-12					12%	255	234	235	#FFEAEB	0	11	4	0	94,0	8,0	2,0		
					Red032-07					7%	255	243	243	#FFF3F3	0	7	3	0	97,0	4,0	2,0		

Pantone Colour	NGA SPC Number	Product Lines	Common Name	Description	Colour Token Name	Low-Light Readability			Color Swatches	Screen %	RGB Equivalent Values			Hexidecimal Values	CMYK Equivalent Values				CIE-LAB Values			Maximum Acceptable ΔE00	
						Red	Green	Blue			R	G	B		C	M	Y	K	L	A	B	Press	Digital
202 U	**61121**	**BNPC DTM HITS ICM LPC MDG MIM TLM TM**	Red-Brown	Typically used for boundaries in HITS and MIMs; roads in ICMs; hypsometric features in JOGAs, LPCs, MDGs, MIMs, TLMs, and TMs.	Red-Brown202	Yes	Yes	Yes		100%	149	80	88	#955058	12	88	67	34	42,4	29,9	7,8	4,0	5,0
					Red-Brown202-91					91%	154	83	94	#9A535E	11	80	61	31	44,0	30,6	7,0		
					Red-Brown202-79					79%	161	94	105	#A15E69	9	70	53	27	47,8	28,5	5,5		
					Red-Brown202-67					67%	170	108	121	#AA6C79	8	59	45	23	52,7	26,3	3,3		
					Red-Brown202-54					54%	180	127	140	#B47F8C	6	48	36	18	58,7	22,7	1,3		
					Red-Brown202-42					42%	194	151	165	#C297A5	5	37	28	14	66,8	17,9	-1,0		
					Red-Brown202-31					31%	203	169	183	#CBA9B7	4	27	21	11	72,6	14,4	-2,4		
					Red-Brown202-21					21%	212	187	201	#D4BBC9	3	18	14	7	78,4	11,3	-3,5		
					Red-Brown202-12					12%	222	206	219	#DECEDB	1	11	8	4	84,4	7,9	-4,4		
					Red-Brown202-07					7%	229	217	230	#E5D9E6	1	6	5	2	88,0	6,1	-4,8		
Process Magenta U	**90342**	**EVC ICM NAVPLAN**	Magenta	Typically used as part of color imagery in ICMs and hypsometric tints in JOGAs and NAVPLAN charts.	Magenta	No	Yes	Yes		100%	239	84	144	#EF5490	0	100	0	0	58,7	64,1	0,0	4,0	5,0
					Magenta-91					91%	226	87	143	#E2578F	0	91	0	0	57,0	59,1	-2,6		
					Magenta-79					79%	227	106	155	#E36A9B	0	79	0	0	60,8	52,1	-3,9		
					Magenta-67					67%	229	126	169	#E57EA9	0	67	0	0	65,2	44,9	-5,3		
					Magenta-54					54%	230	141	180	#E68DB4	0	54	0	0	68,9	38,7	-6,0		
					Magenta-42					42%	231	158	191	#E79EBF	0	42	0	0	73,0	32,3	-6,2		
					Magenta-31					31%	233	175	204	#E9AFCC	0	31	0	0	77,5	25,5	-6,5		
					Magenta-21					21%	235	194	218	#EBC2DA	0	21	0	0	82,6	18,5	-6,6		
					Magenta-12					12%	237	211	230	#EDD3E6	0	12	0	0	87,0	12,3	-6,1		
					Magenta-07					7%	237	221	237	#EDDDED	0	7	0	0	89,7	8,4	-5,8		
688 U	**91021**	**SNC**	Purple-Brown	Legacy color used in SNCs. Replaced by 96532.	Purple-Brown688	Yes	No	No		100%	175	119	149	#AF7795	34	64	19	1	56,6	26,3	-7,0	4,0	5,0
					Purple-Brown688-91					91%	177	122	151	#B17A97	31	58	17	1	57,5	25,8	-6,9		
					Purple-Brown688-79					79%	183	128	157	#B7809D	27	51	15	1	59,9	25,7	-7,1		
					Purple-Brown688-67					67%	189	140	167	#BD8CA7	23	43	13	1	63,6	23,0	-7,1		
					Purple-Brown688-54					54%	196	152	177	#C498B1	18	35	10	1	67,5	20,6	-6,8		
					Purple-Brown688-42					42%	206	168	192	#CEA8C0	14	27	8	0	72,8	18,1	-6,8		
					Purple-Brown688-31					31%	211	178	200	#D3B2C8	11	20	6	0	75,9	15,7	-6,8		
					Purple-Brown688-21					21%	221	196	215	#DDC4D7	7	13	4	0	81,7	11,8	-6,2		
					Purple-Brown688-12					12%	228	212	228	#E4D4E4	4	8	2	0	86,5	8,3	-5,9		
					Purple-Brown688-07					7%	233	221	236	#E9DDEC	2	4	1	0	89,5	6,4	-5,5		
Purple U	**95151**	**LFC Training Area**	Purple	Used for Aeronautical features such as Training Areas, Corridors, Flow, Low Flying Areas, and User Areas.	Purple	Yes	No	No		100%	197	83	181	#C553B5	29	76	0	0	53,0	55,0	-30,0	4,0	5,0
					Purple-91					91%	202	99	188	#CA63BC	26	70	0	0	57,0	50,0	-28,0		
					Purple-79					79%	210	121	197	#D279C5	20	60	0	0	63,0	43,0	-24,0		
					Purple-67					67%	216	140	205	#D88CCD	16	51	0	0	68,0	37,0	-21,0		
					Purple-54					54%	224	162	215	#E0A2D7	12	42	0	0	74,0	30,0	-10,0		
					Purple-42					42%	231	183	224	#E7B7E0	8	32	0	0	80,0	23,0	-14,0		
					Purple-31					31%	237	202	232	#EDCAE8	6	24	0	0	85,0	16,0	-10,0		
					Purple-21					21%	243	219	239	#F3DBEF	4	17	0	0	90,0	11,0	-7,0		
					Purple-12					12%	248	234	246	#F8EAF6	2	10	0	0	94,0	6,0	-4,0		
					Purple-07					7%	251	243	250	#FBF3FA	2	6	0	0	97,0	4,0	-2,0		

Pantone Colour	NGA SPC Number	Product Lines	Common Name	Description	Colour Token Name	Low-Light Readability			Color Swatches	Screen %	RGB Equivalent Values			Hexidecimal Values	CMYK Equivalent Values				CIE-LAB Values			Maximum Acceptable ΔE00	
						Red	Green	Blue			R	G	B		C	M	Y	K	L	A	B	Press	Digital
2577 U	96532	BNPC HITS LPC OPAREA SNC	Hydro Purple	Used for hydrographic features, sector lights, buoys, grids (LPCs), and zoning areas in charts.	Hydro-Purple2577	Yes	No	No		100%	150	123	191	#967BBF	32	43	0	0	56,4	24,6	-31,7	4,0	5,0
					Hydro-Purple2577-91					91%	152	125	192	#987DC0	29	39	0	0	57,3	24,1	-31,3		
					Hydro-Purple2577-79					79%	157	130	197	#9D82C5	25	34	0	0	59,2	23,9	-31,0		
					Hydro-Purple2577-67					67%	162	135	202	#A287CA	21	29	0	0	61,0	23,5	-30,7		
					Hydro-Purple2577-54					54%	171	146	210	#AB92D2	17	23	0	0	64,8	22,3	-29,5		
					Hydro-Purple2577-42					42%	182	159	218	#B69FDA	13	18	0	0	69,2	20,1	-27,0		
					Hydro-Purple2577-31					31%	191	171	224	#BFABE0	10	13	0	0	73,3	17,3	-23,9		
					Hydro-Purple2577-21					21%	202	187	230	#CABBE6	7	9	0	0	78,3	13,6	-19,8		
					Hydro-Purple2577-12					12%	215	205	239	#D7CDEF	4	5	0	0	84,2	9,9	-15,3		
					Hydro-Purple2577-07					7%	223	216	243	#DFD8F3	2	3	0	0	87,5	7,5	-12,4		
Cyan + Black	Foreshore Flats-Topo	N/A	N/A	N/A	N/A	Yes	No	No		N/A	139	180	204	#8BB4CC	31	0	0	12	71,2	-8,0	-16,7	4,0	5,0
Cyan + Black	Foreshore Flats-Hydro	N/A	N/A	N/A	N/A	Yes	No	No		N/A	161	189	208	#A1BDD0	21	0	0	12	75,1	-5,0	-12,8	4,0	5,0
N/A	Paper	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	94,6	1,5	-5,1	N/A	N/A

The following table lists the products cited in the Colour Equivalency Table:

Acronym	Product
BNPC	Bathymetric Navigation Planning Chart
BC	Bottom Contour
DTM	Defence Topographic Map
EVC	Escape and Evasion Chart
GNC	Global Navigation Chart
HITS	Hull Integrity Test Site
ICM	Image City Map
JNC	Jet Navigation Chart
JOG	Joint Operations Graphic
LPC	Littoral Planning Chart
LFC	Low Flying Chart
MDG	MGCP Derived Graphic
MIM	Military Installation Map
NAVPLAN	Navigation Planning Charts
OPAREA	Operational Area Chart
ONC	Operational Navigation Chart
SNC	Standard Nautical Chart
TLM	Topographic Line Map

TPC	Tactical Pilotage Chart
TM	Topographic Map

Annex B
(informative)
Paper types

Several nations provided information on paper types used for map printing.

UNITED STATES (NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY)

The Joint Committee on Printing (JCP) sets standards for paper that is produced by, or for, the U.S. Government. Three basic types of paper shall be used for printing most Maps, Charts & Geodesy (MC&G) graphic products. They are as follows:

a. High Wet Strength Lithographic Map (JCP E-50) – shall be used for all nautical graphic products including Littoral Planning Charts.
b. Offset Book Map, Lithographic Finish (JCP E-30) – shall be used for aeronautical graphic products, City Graphics and most book type graphic publications, such as catalogues and trig lists.
c. Chemical Wood Map, Lithographic Finish (JCP E-40) – shall be used for all topographic products such as the 1:50,000, 1:100,000 and Joint Operations Graphic (Ground and Air).
d. Tyvek synthetic material – shall be used for all Escape and Evasion Charts. Tyvek requires ultraviolet dryers to properly cure the printing inks on the material. Tyvek Charts that are printed without ultraviolet drying have been shown to rapidly oxidize and deteriorate because of on-going chemical reactions between the printing inks and Tyvek material.
e. Digital printing devices shall use paper of equivalent colour, thickness, folding endurance, etc. to ensure that the final printed product best matches the requirements of the end customer. Any deviation from the JCP set of paper, either on lithographic press or digital printer, shall require authorization from NGA.
f. There are various other types of paper used for specific products. These shall be identified in the assignment instructions when required. If a specified paper is not available in the required size or quantity, substitutions of an appropriate quality paper shall be made by the local authority.

GERMANY (BUNDESWEHR GEOINFORMATION CENTRE)

For Print on Demand with maximum print width 1.5 m, three different paper types are used:
- matte inkjet paper
- photo paper semi-matte
- synthetic paper for outdoor use

For Offset Print paper types are as follows:
- LC2 (Map paper) maximum size 72x105 cm, grammage 100 g/m²
- Primaset maximum size 63x88 cm, grammage 115 g/m² und 250 g/m²
- Lumiart maximum size 72x102 cm, grammage 135 g/m²
- Lumisilk (semi-matte) maximum size 72x102 cm, grammage 135 g/m²

CZECH REPUBLIC (OFFICE OF MILITARY GEOGRAPHY AND HYDROMETEOROLOGY)

For Offset Print Map, paper with the following parameters is used:
Grammage: 100 g/m^2
Whiteness: 100–104 %
Moistness: 4–7 %
Roughness: 4,5–5,5 µm

SWEDEN

For Offset Print, mostly coated 80–90 g/m^2 paper is used. Synthetic paper (e.g. Pretex, Synaps OM, Tyvek) is used for special requirements and for some wall maps, glossy paper is utilised. For inkjets, mostly coated and some textile materials is used.

UNITED KINGDOM (DEFENCE GEOGRAPHIC CENTRE)

For all litho printing: Specialist paper - Super white, K Machine finish 100 g/m^2 - Not high wet strength.
Inkjet plotters: Matt Presentation paper 90 g/m^2 supplied in 42" & 60" rolls. Used for normal everyday inkjet printing.
Glossy paper for displays, image maps, etc. - 240 g/m^2 gloss paper.
Office/digital press papers (90 g/m^2, 120 g/m^2, 200 g/m^2 and 250 g/m^2) sizes up to SRA3, matt finish.
Fabric E&E maps are produced using polyester fabric, ordered as "4730 NWT Coated Polyester Reels". Approximate weight 90 g/m^2.

Annex C

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