# New Work Item Proposal: Label Map Segmentation

## Submitted by David Clunie

## On Behalf of Working Group 6

## Introduction/Scope

This work item proposes to add a new segmentation encoding, label maps, to the DICOM standard. Label maps, in which each pixel value represents an index into a list of segmentation properties and colors, are a processing- and coding-efficient method for representing segmentations for any purpose.

## Limitations of Current Standard

Currently, the DICOM standard supports a method (and related IOD and SOP Class) for pixel- or voxel-based segmentation encoding, in which each segmented property is represented as a binary bit plane (or an 8 bit probabilistic or occupancy value). While this allows for overlapping of segments, it is inefficient and difficult to encode large numbers of non-overlapping segmentations, as they require non-trivial processing both to extract from the bit plane encoded data, to assure there is no overlap, and to convert to the label map form that is very commonly used internally and persistently for clinical applications.

The current DICOM bit-plane-based segmentation methods have proven to be awkward both for 3D cross-sectional imaging applications when there are very large numbers of slices and/or structures, and for whole slide microscopy imaging, when there are very large numbers of tiles and/or instance of property classes (e.g., if one wants to individually identify nuclei rather than treat them as one class). They are also typically large and sparse and should compress well but there are very few single bit compression schemes supported by the standard and they do not do well with these types of images.

The proposed label map segmentation encoding is useful for such applications, and reflects common practice for the applicable software. The lack of a label map encoding has resulted in significant criticism and lack of adoption of the standard in lieu of proprietary alternatives in some communities.

## Description of Proposal

The proposed label map segmentation enhanced multi-frame IOD will specify a data structure that provides, for each pixel or voxel in 2D, 3D or tiled pyramidal space, an index value conveying the non-overlapping segment for each pixel, whether it be for a class or individual instance of an entity. Existing data elements for describing segmentations will be reused where appropriate. Bit depth will be sufficient (8, 16 or 32) to encode very large numbers of segments but allow for more compact encoding. The existing palette color photometric interpretation is expected to be used so as to not undermine the widespread implementations in toolkits, and to allow for the use of existing lossless compression schemes without undermining the semantics of monochrome photometric interpretations. Segment properties and color is expected to be conveyed in the existing segmentation description structure so as to be compatible with the existing bit plane segmentation description, without preventing the use of additional separately encoded or well-known DICOM color palette objects.

It is expected that both the label map and bit plane segmentation encoding will peacefully co-exist, and whichever is most appropriate for the specific application will be used by the creators and supported by the implementers. The existing template mechanism used in SR (e.g., to record measurements on segments) will remain applicable to segmentations, whether encoded in bit planes or label maps, since the existing reference mechanism should be reusable unchanged. The relationship to the Microscopy Bulk Simple Annotations object will also be considered.

## Parts of Standard Affected

This work item will affect Parts 3, 4, 6, 16 and 17 of the DICOM standard.

## Resources & Time Line

David Clunie from PixelMed will be editing this supplement, and is supported by a group of implementers from various research and software groups involved in 3D and WSI segmentation, encoding classical image processing and AI output and rendering same, including the NCI Imaging Data Commons (IDC), the highdicom project, the Slim viewer project, Isomics and Kitware (3D Slicer), Radical (OHIF Viewer), Page AI, and Google. It is estimated that the work will take about 12 months, and the supplement will be approximately 20 pages. A first draft will be available by mid-2023.

It is anticipated that four hours of WG-06 meeting time will be required on each of four occasions during 2023 and 2024 to review and approve an early draft as well as public comment, letter ballot, and final text versions of the supplement.