

## STSM Report

# Elaboration of Hyperspectral Image Data from Round Robin Test Acquisition

**REFERENCE:** Short Term Scientific Mission, COST TD1201

**Beneficiary:** E. Keats Webb, SEAHA, University College London & University of Brighton, United Kingdom

**Host:** Marcello Picollo, IFAC-CNR, Italy, [m.picollo@ifac.cnr.it](mailto:m.picollo@ifac.cnr.it)

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Non-invasive investigation tools including digital imaging techniques that aid in recording the condition, informing the care, and expanding the understanding of an object are important for research and conservation documentation of cultural heritage (CH) materials, artworks and archaeological objects. Conservation documentation has included infrared (IR) imaging as a routine technique since the 1930s to provide information about underdrawings, compositional changes, and material differentiation. Infrared imaging has continued to develop especially with the introduction and evolution of digital camera technology and computing. This evolution has recently led to the integration of spectroscopy and digital imaging. Imaging spectroscopy (IS) techniques, including multispectral imaging (MSI) and hyperspectral imaging (HSI), presented advancements in the field for non-invasive analytical tools for CH. Increased application of these techniques for cultural heritage documentation calls for the standardisation of methodologies and definitions of best practices to allow institutions to have reproducible and comparable data. Standards and best practices will be informed by a better understanding of the various imaging acquisition systems used in the CH field.

Working towards standards and best practices is a task of Working Group 1 (WG1) of the European Cooperation in Science and Technology (COST) Action of Colour & Space in Cultural Heritage (COSCH). The working group initiated a Round Robin Test (RRT) of imaging five objects using different imaging and IS systems as a coordinated research effort to better understand the instrumentation, elements of data acquisition, and the affects of the instruments and methodology to the accuracy and reliability of the data. This report presents the elaboration of the selected RRT data supported by COSCH Short Term Scientific Mission (STSM) hosted by the Istituto di Fisica Applicata “Nello Carrara”—Consiglio Nazionale delle Ricerche (IFAC-CNR) under the supervision of Marcello Picollo with the assistance of his colleagues (Andrea Casini, Costanza Cucci, and Lorenzo Stefani). This research builds on Tatiana Vitorino’s 2014 STSM, which initiated the analysis and organisation of the RRT data from IFAC-CNR in the 400-1700 nm range.

This STSM report focuses on the processing and comparison of the RRT data from three institutions acquired in the short-wave infrared (SWIR) region (1000-2500 nm) documenting two of the RRT targets, a test panel painting and a calibration standard. The research examined the different materials used for underdrawings in the test panel and assessed the spectral and spatial resolution of HSI systems using both the test panel and calibration standard. HSI systems used by CH institutions have different spectral and spatial resolutions influencing the accuracy and reliability of the resulting data. Understanding these systems can inform the standardisation of methodologies and the development of best practices.



**RRT Target**

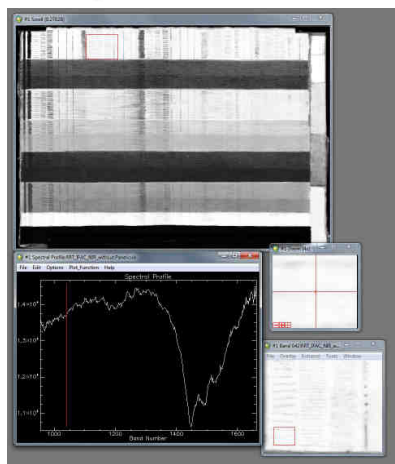
Lead- and tin-based metalpoint	Wood Glue	1 <sup>st</sup> Gypsum Ground	Canvas	2 <sup>nd</sup> Gypsum Ground
	Solid line	1/2 mm		
	1 mm	2 mm		
	Sfumato			
	Solid line	1/2 mm		
	1 mm	2 mm		
Graphite	Solid line	Spolvero (line) outlined with traces		
	Spolvero (dots) outlined with traces	1/2 mm		
	1 mm	2 mm		
	Sfumato			
	Solid line	Spolvero (line) outlined with traces		
	Spolvero (dots) outlined with traces	1/2 mm		
Charcoal	Solid line	Spolvero (line) outlined with traces		
	Spolvero (dots) outlined with traces	1/2 mm		
	1 mm	2 mm		
	Sfumato			
	Solid line	Spolvero (line) outlined with traces		
	Spolvero (dots) outlined with traces	1/2 mm		
Watercolour	Solid line	Spolvero (line) outlined with traces		
	Spolvero (dots) outlined with traces	1/2 mm		
	1 mm	2 mm		
	Sfumato			
	Solid line	Spolvero (line) outlined with traces		
	Spolvero (dots) outlined with traces	1/2 mm		

Spectralon Multi-Component Wavelength Calibration Standard (diameter ~ 90 mm). Image from Vitorino.

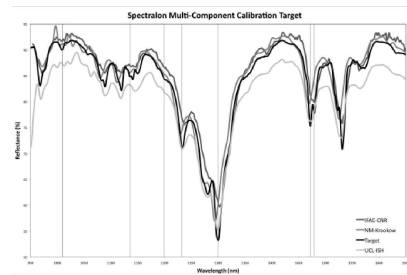
The painted panel target with the left image showing the underdrawing materials, lines, and line patterns before the paint was added, and the right image shows the different paint materials used and the varying thicknesses. Figure from Vitorino.

Extracting data to assess spatial & spectral resolution

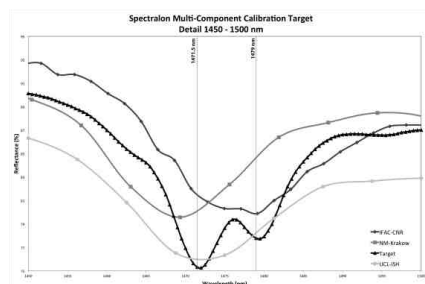
Extracting data to assess spectral resolution



Screenshot from ENVI Classic interface when taking measurements of underdrawing materials. The top image indicates where on the object the measurement is being taken with the two bottom right boxes including more specifics for the measurement location. The plot on the bottom left shows the spectral reflectance of a charcoal line on the panel target.



Comparison of the spectral reflectance of the Spectralon target from IFAC-CNR, NM Krakow and UCL-ISH with the measurements from the manufacturer.



Detail view (1450-1500 nm) of the spectral reflectance of the Spectralon target from IFAC-CNR, NM Krakow, UCL-ISH, and the manufacturer. The vertical lines mark the prioritised wavelengths indicated by the manufacturer.