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# High-Resolution Multispectral Imaging and Analysis Systems for the Very-Long-Term Monitoring of Photographs, Paintings, Fabrics, Documents, Books, and Other Works of Artistic and Historical Importance

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## Abstract

*Development of new multispectral imaging and image-change analysis systems allows high-resolution, full-area, non-destructive and zero-contact monitoring (without the necessity of removing works framed under glass or plastic sheets from their frames) of photographs, paintings, fabrics, documents, books, and other works of artistic and historic importance with very large data sets consisting of ten thousand or more discrete colorimetric data points for the short-term and long-term monitoring of full-tonal-scale colorimetric changes (including in the UV and IR regions) in a fully-time-integrated fashion that might take place in the full image area and in the support material (recto and verso) over time. Irregularities in image deterioration and/or staining brought about by localized variations with the materials and "processing" employed in the creation of the work, the inevitably non-uniform contact with mounting, framing, and storage materials over time, and the effects of exposure to non-uniform lighting, environmental and "micro-climate" temperature and relative humidity conditions, can be assessed and compared over long periods of time in all areas of an image – including within very small image details. This paper attempts to consider the formidable technical challenges of very-long-term monitoring in the context of the now more than 2,000-year-old Dead Sea Scrolls in Israel, and the ongoing programs to systematically multispectrally-image, monitor, and preserve the delicate parchment scrolls and scroll fragments. Strategies that might be able to accomplish such very-long-term monitoring goals are suggested.*

## Proposal

As an example of a long-term monitoring project and its associated workflow, salted paper photographic prints made by William Henry Fox Talbot, Hill and Adamson and Hill, and others in the collection of the Canadian Photography Institute of the National Gallery of Canada were imaged with the MegaVision Multispectral Imaging and Analysis System to illustrate how multispectral imaging can be applied to the long-term monitoring of photographs and collections of other materials. The photographs – made more than 150 years ago – vary greatly in condition, with some still in excellent condition while others exhibit severe, irregular fading, and loss of detail.

The system builds upon and enhances the capabilities of the MegaVision Multispectral System in use at the Israel Antiquities Authority in Jerusalem to image and monitor the Dead Sea Scrolls, which were made more than 2000 years ago. With the capture of monitoring data, high-resolution color images with a color accuracy only possible with many spectral bands are also simultaneously captured. The total capture time for sixteen spectral bands (one 365nm UV exposure, exposures for 10 spectral bands in the visible region, and 5 IR bands) is approximately three minutes.

Additional multispectral imaging projects that will be discussed include the 1215 Magna Carta in the British Library, President Lincoln's handwritten Gettysburg Address, early drafts of the Declaration of Independence, and other documents in the Library of Congress, historic manuscripts in Saint Catherine's Monastery in the Sinai Desert in Egypt, and David Livingston's 1871 Africa Diaries.

As a further illustration of the monitoring of deteriorating objects, modern salted paper prints were made by Mike Robinson, an historian and contemporary maker of photographs using 19th century processes in Toronto, Ontario, Canada, utilizing a number of process variations, including prints "stabilized" with a sodium chloride solution but not fixed with sodium thiosulfate, and prints fixed and washed, and then gold toned or left untoned.

These prints are currently being subjected to a range of accelerated aging techniques in the permanence testing laboratory at Wilhelm Imaging Research to establish baseline data for the intrinsic stability of salted paper prints. The tests include accelerated light exposure with 3000K high-CRI (>95) LED illumination to simulate museum, gallery, and archive display conditions; and tests conducted with glass-filtered and UV-filtered Cool White (F-6) fluorescent illumination. Tests with Hoya L-37 filtered xenon arc illumination to simulate indoor indirect daylight through window glass are also being prepared. Multi-temperature Arrhenius dark storage tests (50% RH at 57°C, 64°C, 71°C, and 78°C), ozone resistance tests; high-humidity resistance tests, and water-resistance tests are also being conducted.

The light-stability data obtained from the tests with the process variations discussed above will in the future be compared with data generated with both xenon arc and LED microfading test equipment. In addition, light-stability reciprocity relationships between the extremely high illumination level, short-term light exposure employed by microfading test units, and the much lower level, longer-term, temperature- and humidity-controlled conditions provided in the laboratory accelerated light fading tests at Wilhelm Imaging Research, will also be explored in a future project. The collected data can be thought of as an "accelerated" monitoring project that greatly speeds up fading, staining, and a variety of other deterioration processes.

Finally, the long-term preservation of the spectral data captured with non-destructive multispectral imaging and continued access to the individual high-resolution image files

captured at each wavelength, calibration, and reproducibility of the system over very long periods of time will be discussed and several proposals will be offered.

## References


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## Author Biographies

*Ken Boydston is the President and Chief Color Scientist of MegaVision, Inc., based in Santa Barbara, California. Boydston led the development of the high-resolution, MegaVision Multispectral Imaging and Analysis System which was introduced in 2007 and, with Boydston's collaboration, has been used to image, to monitor with very large colorimetric data sets, and to conduct forensic analysis of the Dead Sea Scrolls in Israel and many other national and world cultural heritage treasures, including:*

- *Qeiyafa Ostracon (Israel Antiquities Authority) Earliest known Hebrew writing est. 1,000 BC*
- *Waldseemueller map (United States Library of Congress) First map of America, 1507*
- *Gettysburg Address (United States Library of Congress) Nicolay and Hays drafts*
- *Mughal illuminated manuscript (Walters Museum, Baltimore, Maryland)*
- *16th Century Mughal Emperor Akbar's "Pearl of the Parrot of India," Comaro Missal (Private Collector)*
- *Léon Bonvin Watercolors (Walters Museum) Oxyrhynchus Papyri (Oxford University)*
- *Declaration of Independence (United States Library of Congress)*
- *Selected pigment studies (Getty Museum of Art, Los Angeles, California)*
- *Palimpsest collection and other manuscripts (St. Catherine's Monastery)*
- *Dead Sea Scrolls (Israel Antiquities Authority)*
- *David Livingstone 1871 Africa Diaries (National Trust for Scotland)*
- *Artists' works: Monet, Picasso, Delacroix, Michelangelo, Gauguin, others (Santa Barbara Museum of Art, Santa Barbara, California)*
- *Daguerreotypes (United States Library of Congress)*
- *Various papyri and manuscripts (State Library of Austria)*
- *Vercelli Book (Museo del Tesoro del Duomo)*
- *Codex Vercellensis (Museo del Tesoro del Duomo)*
- *Vercelli Mappamundi (Museo del Tesoro del Duomo)*
- *1215 Magna Cartas (British Library, Lincoln Salisbury Cathedral)*
- *Martellus Map (Beinecke Rare Books Library, Yale University)*
- *Jagiellonian Globe (Jagiellonian University Museum)*

***Henry Wilhelm** is Founder and Director of Research at Wilhelm Imaging Research, Inc. in Grinnell, Iowa. With work beginning in 1971, Wilhelm and his colleagues have assembled the world's largest reference collection of analog and digital color print materials and associated permanence data. With contributing author Carol Brower Wilhelm, he wrote "The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures," published in 1993. The complete 761-page book is available in PDF-A format at no cost from www.wilhelm-research.com. Wilhelm has authored or co-authored more than 30 technical papers that were presented at conferences sponsored by the Society for Imaging Science and Technology (IS&T), the Imaging Society of Japan (ISJ), and the American Institute for Conservation (AIC) in the United States, Europe, and Japan. He was one of the founding members of American National Standards Institute (ANSI) Committee IT-3, which was established in 1978. The Committee is now known as ISO Working Group 5/Task Group 3 (a part of ISO Technical Committee 42). Wilhelm is currently serving with Shigeo Suga of Suga Test Instruments Co., Ltd., Tokyo Japan, as Co-Project Leaders for the development of the new ISO 18937-4 accelerated test methods standard for LED illumination sources. Wilhelm received an Honorary Doctor of Science Degree from Grinnell College in 2011.*

***John McElhone** was the Chief of Conservation and Research at the Canadian Photography Institute of the National Gallery of Canada, in Ottawa, Ontario, Canada, until he retired from that position at the end of 2017 to focus on scholarly research and writing on 19th-century photographic processes and practice. McElhone obtained degrees in biochemistry, photography, and art conservation before joining the National Gallery in 1986 as the first photograph conservator employed by that institution. He spent twenty-four years working in that capacity before becoming Chief Conservator. More recently, he had returned to more direct involvement with photographs and conservation research as a key part of his responsibilities at the Canadian Photography Institute of the National Gallery of Canada when the Institute was launched in 2016.*

***Richard M. Adams,** Ph.D., is an Associate Professor in the School of Graphic Communications Management at Ryerson University, Toronto, Ontario, Canada. He teaches courses in document design, web design, and materials science for print. Adams's research interests include color management, electronic documents, and web design. Before moving to Ryerson, he was a color management specialist with the training division of X-Rite, Inc., and was a research scientist at the Graphic Arts Technical Foundation (now the Printing Industries of America). After completing his Ph.D. in botany, Adams went on to receive a master's degree in printing technology from Rochester Institute of Technology.*