# MOLAB: A EUROPEAN MOBILE LABORATORY ENABLING ADVANCED STUDIES IN ARCHAEOMETRY

## MOLAB: EURÓPAI MOBIL LABORATÓRIUM KIEMELKEDŐ ARCHEOMETRIAI KUTATÁSOKHOZ•

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### *Abstract*

*IPERION HS (Integrating Platforms for the European Research Infrastructure ON Heritage Science) project integrates distributed national facilities of recognized excellence in Heritage Science in order to foster trans-disciplinary activities aimed to the interpretation, preservation, documentation and management of Cultural Heritage. IPERION HS offers access through three platforms: ARCHLAB, FIXLAB and MOLAB (Mobile LABoratory), to a wide range of high-level scientific instruments, methodologies, expertise, data and tools distributed in 23 countries in Europe and in the Associated Countries for advancing knowledge and innovation in the field of Heritage Science. In this paper, the MOLAB platform of IPERION HS is presented; useful information regarding the access procedure for users will be also provided. Finally, the application of one of the portable and non-invasive techniques available in the MOLAB platform employed for the study of a Caravaggio painting will be briefly reported.*

*The Hungarian version of this paper is available here (translated by Veronika SZILÁGYI)*

### *Kivonat*

*Az IPERION HS projekt (Integrating Platforms for the European Research Infrastructure ON Heritage Science) európai országok elismert örökségtudományi kutatóhelyeit foglalja egy egységes pályázati rendszerbe azzal a céllal, hogy elősegítse a humán és reál tudományterületek közötti interakciót kulturális örökségünk megértése, megőrzése, dokumentálása és kezelése érdekében. Az IPERION HS három fő platformja (ARCHLAB, FIXLAB és MOLAB) révén lehetőség nyílik magas színvonalú műszerek, speciális módszerek, szakértői segítség, adattárak és adatbázisok használatára 23 európai és a pályázathoz társult egyéb országban. Tanulmányunkban az IPERION HS projekt MOLAB platformját mutatjuk be, a pályázati úton történő hozzáférés ismertetésével. Egy esettanulmány keretében Caravaggio egyik festményének a MOLAB egyik mobil és roncsolásmentes módszerével történő vizsgálatát részletezzük.*

KEYWORDS: MOLAB, IPERION HS, RESEARCH INFRASTRUCTURES, HERITAGE SCIENCE

KULCSSZAVAK: MOLAB, IPERION HS, KUTATÓHELYEK, ÖRÖKSÉGTUDOMÁNY

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## *Introduction*

The tangible and intangible Cultural Heritage is a fundamental part of the European identity. Given its complexity and vastness, the study of the Cultural Heritage is a global challenge for science and the European society at large. IPERION HS (Integrating Platforms for the European Research Infrastructure ON Heritage Science) that started at April 2020 has been approved as a new HORIZON 2020 project for European research infrastructures (E-RIHS PP, Striova & Pezzati 2017, Bertrand et al. 2020). IPERION HS integrates distributed national facilities of recognized excellence in Heritage Science and connects researchers in the Humanities and Natural Sciences that work in the major research centres in heritage science, outstanding research institutes, prestigious research laboratories, conservation centres in heritage science and universities. The aim of IPERION HS is to foster, through a unique and sustainable plan of activities, a trans-disciplinary culture of exchange and cooperation for the interpretation, preservation, documentation and management of Cultural Heritage. IPERION HS partners have a long-term experience gained through several milestone projects supported by the EC such as Labs-TECH, Eu-ARTECH, CHARISMA, IPERION CH (see below the links to CHARISMA, DARIAH ERIC 2017, Eu-ARTECH, IPERION CH projects, Pallot-Frossard 2016a, 2016b). IPERION HS offers Transnational Access (TNA), through three platforms: ARCHLAB, FIXLAB and MOLAB, to a wide range of high-level scientific instruments, methodologies, expertise, data and tools distributed in 23 countries in Europe and in the Associated Countries for providing knowledge and innovation in the field of Heritage Science. In this paper, the MOLAB (Mobile LABoratory) platform of IPERION HS will be presented, in particular its mission, structure and access procedure. Following, a MOLAB measurements campaign carried out by applying one of the advanced techniques available on the MOLAB platform on a painting by Caravaggio will be briefly presented.

## *The MOLAB Platform of IPERION HS*

A huge part of historical European patrimony consists of monuments, sculptures, buildings and large size artworks that cannot be moved from their location. Furthermore, even in the case of movable patrimony (such as paintings, ceramics, gems, manuscripts, etc.), it could be often difficult, if not impossible, to move them to a scientific laboratory, because it implies high risks and costs connected with their transportation and often their fragility. Therefore, non-invasive studies must be necessarily carried out in-situ by using portable instrumentation. The MOLAB platform of IPERION HS offers access to a network of facilities from 10 European countries that provide, under a unified management structure, to a wide range of mobile instrumentation, analytical techniques and related expertise, to perform in-situ non-destructive measurements (Brunetti 2007, Miliani et al. 2010, Brunetti et al. 2016a, 2016b). In total, 48 advanced and integrated portable analytical techniques are available in the platform, including point analysis, 2D/3D imaging and multispectral / hyperspectral imaging. Furthermore, recently in-ground and aerial remote sensing techniques are also available for the exploration, survey and documentation of archaeological sites and monumental heritage. In **Table 1.**, we report all analytical techniques available in the MOLAB platform for users.

In many cases, the results obtained during the MOLAB access are provided in real-time; permitting an immediate discussion with users and all the collected data belongs to users for publishing and disseminating. MOLAB users are usually Heritage researchers from academy, public institutions and industry (conservation scientists, art-historians, archaeologists and restorers) who ask single or multi-technique analysis in order to investigate art-historical or archaeological aspects, such as the materials composing the artworks, the execution techniques, dating, the presence of under-drawings in paintings, etc., or aimed on the state of conservation of artworks for carrying out research on innovative methods in restoration, preservation, cleaning, etc.

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**Table 1.:** Analytical techniques available in the MOLAB platform of IPERION HS
**1. táblázat:** AZ IPERION HS MOLAB platformjában hozzáférhető módszerek

| MULTI-/HYPERSPECTRAL IMAGING/MAPPING | 2D/3D analysis | POINT ANALYSIS | REMOTE SENSING |
|---|---|---|---|
| Fluxgate Gradiometry | 3D structure-light scanner and 3D laser scanners | Cytometer, DNA and RNA sequencer, luminometer lumitester, PCR and electrophoresis system | Electrical Resistivity Tomography (ERT) |
| Reflection VIS Hyperspectral Imaging (400-1000 Nm) | Acoustic tomography | Electrochemical impedance spectroscopy | Ground Penetrating Radar |
| UV-VIS Induced Fluorescence Hyperspectral Imaging (450-1000 Nm) | Digital Holographic Speckle Pattern Interferometry (DHSPI) | Hyphenate LIBS/LIF/Raman | Ground Penetrating Radar - medium and high frequency antenna |
| NIR Hyperspectral Imaging (900-2500 Nm) | High resolution digital microscopy | Hyphenate XRD/XRF | Laser Scanning |
| Macro XRF Scanning | NMR depth-profiling/relaxometry | Micro-Raman (532 nm) | Magnetic susceptibility measurements |
| Micro X-Ray Fluorescence Mapping (MXRF) | Optical Coherence Tomography (1960 nm) | Particle Induced X-ray Emission (PIXE) | Remote LIBS spectroscopy |
| XRF Confocal Mapping | Optical Coherence Tomography (850 nm) | Raman (785 & 1064 nm) | Remote Raman/LIF spectroscopy |
| Scanning VIS-NIR Multispectral Reflectography (395 – 2500 nm) | Optical profilometry | Total reflection mid/near-FTIR | Remote SWIR hyperspectral imaging |
| Imaging Methods and Scanning applications for Non-Invasive Dendrochronology | Terahertz imaging | UV-VIS fluorescence time-decay | Remote UV LIF spectroscopy |
| Thermography (SIRT) | | UV-VIS-NIR fluorescence | Remote VIS/NIR hyperspectral imaging |
| UAV based - VIS Multispectral (+RGB) & IRT Imagery | | UV-VIS-NIR reflectance | Remote VIS/NIR spectral imaging for large area survey |
| | | X-Ray Fluorescence (XRF) | Soil conductivity |
| | | XRD mapping | Soil resistivity |
| | | | UAV Photogrammetry and aerial multispectral models |
| | | | UAV-LiDAR |

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## *Access to the MOLAB Platform of IPERION HS*

The access procedure to MOLAB starts with the submission of a proposal by users. Application form is available online. Applications will be evaluated with two cut-off deadlines per year. The first call is opened from 2 November 2020. During preparation phase of the proposals, the users can contact the Access Office (access@iperionhs.eu) to discuss both the administrative and scientific issues on how to prepare the proposal. This process strongly improves user projects and gives more chances for a successful application. Those users who work in an institution/SME established in a Member State of the European Union, an EU Associated State or a developing country can require Transnational Access in a MOLAB infrastructure located in a different country. The evaluation phase of the proposals consists of a two-step process. In the first step: during the technical evaluation, the feasibility of the analysis and the coherence of the time requested for measurements will be evaluated. If users have submitted a multi-analysis proposal, its feasibility will be checked by all the scientists in charge of the selected instruments. The feasible proposals will be transferred to an independent, international Peer Review Panel (PRP) of experts who are recognised for their expertise in the field of conservation and scientific studies of Cultural Heritage. During the second evaluation, the scientific excellence, novelty and impact of the proposals are judged. The entire evaluation process is expected to be completed in a few weeks after the submission deadline. In case of both positive evaluations, the MOLAB access will be scheduled and it will be realized in general, no later than 12 months from the final evaluation. All costs of the activity will be covered by IPERION HS. Each submitted project will be of variable duration depending on the nature and complexity of the study, typically each intervention is expected to last for 7 days. At the end of the MOLAB access, users will be asked to complete post access reports and surveys within 2 weeks. Furthermore, users are requested to publish the results of IPERION HS supported projects in open access international scientific literature. A complete description of the MOLAB platform and the access procedure can be consulted on the IPERION HS website: http://www.iperionhs.eu.

## *A challenging MOLAB case-study*

Many artworks such as large-dimension paintings are practically unmovable and consequently difficult to analyse. Furthermore, often their large dimensions can inhibit the analysis of the entire work for reasons due to the time restrictions available for measurements, thus the analyses are often limited to selected parts of the artwork. The advanced portable analytical techniques and innovative methodologies available in the MOLAB platform allow us to overcome these limitations and to approach numerous challenges in the study of heritage objects. Here we briefly report the study of a large dimension painting by Caravaggio entitled "Seven Works of Mercy" and located at the Pio Monte della Misericordia Museum in Naples (Italy). The study of the painting has been carried out by applying the non-invasive Macro X-ray Fluorescence (MA-XRF) imaging technique. The MA-XRF technique consists of the scanning of the painted surface by using a micrometric X-ray beam and the analysis provides the images of the chemical elements distributed on the painted surface of the samples under study. The MA-XRF technique allows us to obtain information concerning the nature and origin of raw materials used by the artist, the execution technique, the artistic process, the state of conservation of artworks and in some cases to obtain information on their authenticity. An advantage of the MA-XRF technique is that its results are "images" of easy and immediate interpretation even for users with expertise outside the scientific sectors (e.g. conservatories, archaeologists and art-historians, etc.)(Romano et al. 2017, Bicchieri et al. 2020, Cavaleri et al. 2020, Caliri et al. 2020, Nervo et al. 2020). During the MOLAB campaign focused on the study of the Caravaggio painting, a high-performance MA-XRF scanner has been employed, that is recently among the most advanced systems available in terms of lateral resolution of the images (up to 25 microns), dimensions of the analysable area (110×70 cm) and scanning speed up to 10 cm/s. The entire surface of the huge painting (3.9×2.6 m) was analysed by operating in total 25 scanning at a maximum speed of 10 cm/s and with a lateral resolution of 1 mm. In order to analyse the entire pictorial surface, a scaffold was installed in front of the painting (**Fig. 1.**) and the scanning system was assembled and disassembled during the measurements on the different scaffold floors. The entire MA-XRF analysis lasted a total of 5 working days, also including the scaffold operations.

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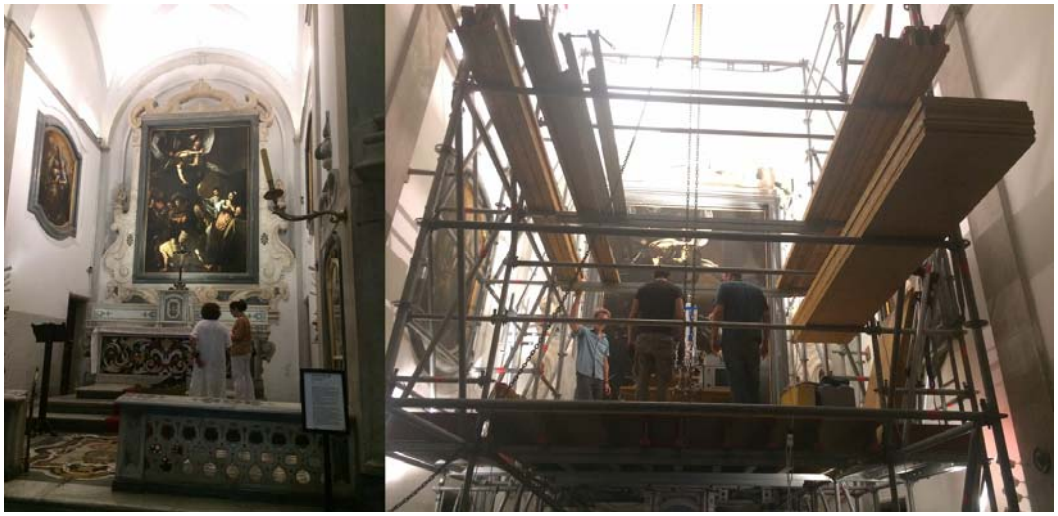

**Fig. 1.:** MOLAB measurement campaign for the study of a Caravaggio painting at the *Pio Monte della Misericordia Museum* in Naples (Italy)

**1. ábra:** A nápolyi *Pio Monte della Misericordia Museum* Caravaggio oltárképének MA-XRF vizsgálata a MOLAB pályázati mérése keretében

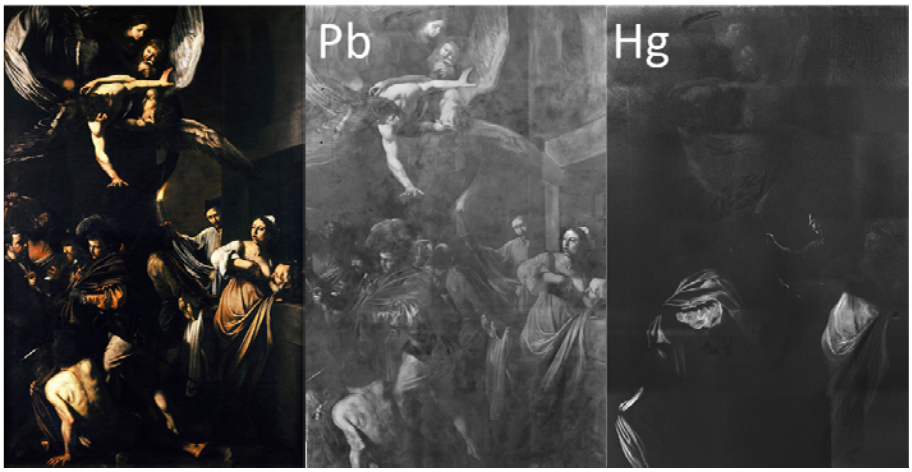


**Fig. 2.:** Pb and Hg elemental maps obtained by applying the MA-XRF technique on "Seven Works of Mercy" by Caravaggio

**2. ábra:** Az MA-XRF módszerrel Caravaggio*" Az irgalom hét cselekedete"* című oltárképéről készült Pb és Hg elemeloszlási térképek

The elemental maps obtained have identified the pigment palette used by Caravaggio, mainly characterised by Ca, Cu, Fe and Pb based pigments. As examples, the Pb and Hg elemental maps obtained by the MA-XRF application are shown in **Fig. 2.** In addition, MA-XRF technique allowed us to study the creative process of Caravaggio, by unveiling a hidden painting of a man that was originally painted but never completed. Indeed, Caravaggio covered the figure and re-painted the same man with "other clothes" in a different figurative composition. Finally, due to the MA-XRF maps the artist painting technique could be highlighted based on the known "*tecnica a risparmio*" visible through the distribution maps of Pb, Cu and Ca.

## *References*

BERTRAND, L., ANGLOS, D., CASTILLEJO, M., CHARBONNEL, B., DAVID, S., de CLERCQ, H., DUBRAY, F. & SPRING, M. (2020): D. 9.3 E-RIHS Scientific Strategy v. 1.0. *Manuscript*, European Commission. 79 p.

BICCHIERI, M., BIOCCA, P., CALIRI, C., & ROMANO, F. P. (2020): New discoveries on Leonardo da Vinci drawings. *Microchemical Journal* **157** 104844.

BRUNETTI, B., MILIANI, C., ROSI, F., DOHERTY, B., MONICO, L., ROMANI, A. & SGAMELLOTTI, A. (2016a): Non-invasive investigations of paintings by portable

instrumentation: the MOLAB experience. *Topics in Current Chemistry* **374/1** 10. 35 p.

BRUNETTI, B., MILIANI, C. & SGAMELLOTTI, A. (2016b): MOLAB growth, aims and results. *Technè. La science au service de l'histoire de l'art et de la préservation des biens culturels* **43** 32–40.

BRUNETTI, B. G., MATTEINI, M., MILIANI, C., PEZZATI, L. & PINNA, D. (2007): MOLAB, a mobile laboratory for in situ non-invasive studies in arts and archaeology. In: DICKMANN, K., FOTAKIS, C., ASMUS, J.F. eds., *Lasers in the Conservation of Artworks*. Springer, Berlin, Heidelberg. 7–54.

CALIRI, C., BICCHIERI, M., BIOCCA, P. & ROMANO, F. P. (2020): In situ macro X-ray fluorescence scanning on a Leonardo da Vinci portrait. *X-ray Spectrometry* **special issue** 1–9. https://doi.org/10.1002/xrs.3193.

CAVALERI, T., BUSCAGLIA, P., CALIRI, C., FERRARIS, E., NERVO, M. & ROMANO, F. P. (2020): Below the surface of the coffin lid of Neskhonsuennekhy in the Museo Egizio collection. *X-ray Spectrometry* **special issue** 1–14. https://doi.org/10.1002/xrs.3184.

CHARISMA (Cultural Heritage Advanced Research Infrastructures: Synergy for a Multidisciplinary Approach to Conservation / Restoration), https://cordis.europa.eu/project/rcn/92569_en.html

DARIAH ERIC (2017). Annual Report. https://www.dariah.eu/wp-content/uploads/2018/12/DARIAH-Annual-Report-2017.pdf

E-RIHS PP (The European Research Infrastructure for Heritage Science Preparatory Phase), https://cordis.europa.eu/project/rcn/209507/factsheet/en

Eu-ARTECH (Access, Research and Technology for the conservation of the European Cultural Heritage), https://cordis.europa.eu/project/rcn/73812_en.html.

IPERION CH (Integrated Platform for the European Research Infrastructure ON Cultural Heritage) is an ongoing project, https://cordis.europa.eu/project/rcn/198068/factsheet/en

MILIANI, C., ROSI, F., BRUNETTI, B. G. & Sgamellotti, A. (2010): In situ non-invasive study of artworks: the MOLAB multitechnique approach. *Accounts of Chemical Research* **43/6** 728–738.

NERVO, M., ROMANO, F. P., CALIRI, C., PICCIRILLO, A., TRIOLO, P., DEMONTE, D., GATTI, A., VERGALLO, E., CARDINALI, M. & FERRERO, M. (2020): "Costruzione del viadotto": MA-XRF in the pictorial executive technique of Agostino Bosia. *X-ray Spectrometry* **special issue** 1–10. https://doi.org/10.1002/xrs.3161

PALLOT-FROSSARD, I. (2016a): From CHARISMA to IPERION CH and E-RIHS: towards a European research infrastructure for heritage science. *Technè. La science au service de l'histoire de l'art et de la préservation des biens culturels* **43** 46–49.

PALLOT-FROSSARD, I. (2016b): From Eu-ARTECH to CHARISMA: Expanding the expertise and scope of the research infrastructure. *Technè. La science au service de l'histoire de l'art et de la préservation des biens culturels* **43** 23–25.

ROMANO, F. P., CALIRI, C., NICOTRA, P., DI MARTINO, S., PAPPALARDO, L., RIZZO, F. & SANTOS, H. C. (2017): Real-time elemental imaging of large dimension paintings with a novel mobile macro X-ray fluorescence (MA-XRF) scanning technique. *Journal of Analytical Atomic Spectrometry* **32/4** 773–781.

STRIOVA, J. & PEZZATI, L. (2017): The European Research Infrastructure for Heritage Science (E-RIHS). *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* **42** 661–664.