National Leadership Grants - Museums

Sample Application MG-256174-OMS-24
Project Category: Collections Stewardship

Los Angeles County Museum of Art

Amount awarded by IMLS:	$744,095
Amount of cost share:	$0

The Los Angeles County Museum of Art will research and test environmentally sustainable solutions for art packaging that will appropriately protect cultural heritage objects during transportation, while substantially reducing the museum field's environmental impact. The initiative will bring together museum and art gallery professionals—art preparators, registrars, collection managers, conservators, and scientists—with an international committee of expert advisors from the fields of engineering, manufacturing, and art packing and shipping. The project will gather current research on sustainable materials and art packing systems, and develop and test alternative systems. The aggregated research and conclusions will be published as a manual for field practitioners on how to design, build, and pack art shipping crates with methods and materials that reduce the carbon footprint and negative environmental impact of art transportation, while providing optimal protection to cultural heritage objects.

Attached are the following components excerpted from the original application.

- Narrative
- Schedule of Completion
- Digital Product Plan
- Performance Measurement Plan
- Data Management Plan

When preparing an application for the next deadline, be sure to follow the instructions in the most recent Notice of Funding Opportunity for the grant program to which you are applying.

Carbon Reduction and Art in Transit (CRAIT)

I. Project Justification

Introduction: The Los Angeles County Museum of Art (LACMA) respectfully requests a $744,095 National Leadership Grant (NLG) from the IMLS to research and test environmentally sustainable solutions for art packaging that will appropriately protect cultural heritage objects during transportation while substantially reducing the museum field's environmental impact. The **Carbon Reduction and Art in Transit (CRAIT)** initiative will bring together museum and art gallery professionals—art preparators, registrars, collection managers, conservators, and scientists—with an international committee of expert advisors from the fields of engineering, manufacturing, and art packing and shipping to gather current research on sustainable materials and art packing systems, develop and test alternative systems, and publish the aggregated research and conclusions in a practical manual on how to design, build, and pack art shipping crates with methods and materials that reduce the carbon footprint and negative environmental impact of art transportation while providing optimal protection to cultural heritage objects.

Though art museums can be notoriously inefficient—with energy-draining climate control and lighting systems compounded by aging infrastructure—and often rely upon wasteful practices to minimize risk to cultural heritage objects, LACMA aims to be a leader in creating sustainable practices for the museum field. As described in the Organizational Profile, LACMA is in the midst of several initiatives that aim to reduce energy consumption, reduce its use of fossil fuel-based products, build sustainable infrastructure, and partner with Indigenous communities to learn how to be better stewards of their cultural knowledge and, in turn, our land and natural resources. These commitments, at every level of the museum, combined with our extensive collaborative networks with colleagues across all sectors in the art world, make LACMA uniquely positioned to carry out the CRAIT initiative.

As the impacts of climate change become more pronounced and collective support from every sector grows to mitigate this crisis, we aim to develop and disseminate informed practices in art packing that can phase out the fossil fuel-based products and single-use materials that are heavily relied upon in art packing systems.

<u>Program Goal and Associated Objectives</u>: The CRAIT initiative aligns with three objectives under IMLS Goal 3: Advance the museum field's ability to identify new solutions that address high-priority and widespread collections care or conservation issues. Our overarching goal is to reduce greenhouse gas emissions from our art packing systems by 50% by 2030, in line with the National Climate Task Force's goals, and share the methods to do so with the museum field. The project will address the following objectives:

3.1: We will **develop and disseminate new collections management tools**, specifically a manual of informed practices to build art packing systems that balance care for art with care for our environment. Results will be implemented at LACMA and shared with the museum and gallery fields to encourage broader adoption.
3.2: We will support the **development of training and professional development tools** and resources by developing and publishing a manual of informed practices for art packing that can be used by the museum field as well as galleries and other institutions responsible for the transportation of artwork.
3.3: We will **research the efficacy and safety of alternative materials** for crating, insulating, and cushioning art objects that have a lower carbon footprint than those used in current systems. Testing and comparison of materials will focus on the performance of packing systems for shock and vibration-dampening and temperature and humidity mitigation.
3.4: We will **convene an advisory committee of experts** from disciplines related to art packing from the non-profit, commercial, and education sectors. Advisors will work with the core team to gather existing research and data on sustainable materials and art packing systems, which we will aggregate with the data resulting from our research into a publication of informed practices for packing art objects. Additionally, advisors will contribute to research design and result analysis discussions and ensure wide dissemination across the museum field.

<u>Identified Need</u>: Given the international distribution and number of museums–an estimated 104,000 worldwide, according to UNESCO, of which 35,000 or nearly one-third are located in the United States–the transportation of objects and the types of materials used to protect cultural heritage while in transit represent a major contribution to waste and greenhouse gas emissions produced by cultural institutions. With well-established research verifying that Earth's temperature is

steadily rising and a large proportion of the world's population is projected to reside in unlivable regions by the end of the century, calls to address the global challenge of climate change have reached every aspect of society, including museums that steward and protect our cultural heritage. As the country with the highest concentration of museums, the U.S. must consider climate impact when developing informed practices for the entire field. The CRAIT team has identified art packing as an area where museums can reduce the industry's carbon footprint by identifying alternatives to polyethylene, polyurethane foams, extruded polystyrene (all fossil fuel-based), and wood products used to protect art in transit.

Museums have a mandate to make their collections accessible to the public. To this end, institutions have active loan programs that facilitate sharing collections. LACMA, for example, saw nearly 5,000 artworks shipped for exhibitions, 500 for outgoing loans, and 2,000 objects shipped for new acquisitions and incoming long-term loans in fiscal year 2023. Over the last few decades, as traveling exhibitions and out-going loans became more common, conservators and conservation scientists began researching the effects of transit on artworks. The professionalization of the sector and evidence of the effects of shock, vibration, and temperature and relative humidity changes on artworks resulted in complex packing systems that use more materials and rely heavily on petroleum-based products and other materials with high carbon footprints.

A typical packing system painting or object at LACMA (figure 1) consists of a Medium Density Overlay (MDO) or plywood box (image on the left) surrounded by 2" thick polyethylene foam pads on all six sides for cushioning (shown in white) and solid planks of 2" polystyrene (XPS) for insulation (shown in blue). The outer shell (image on the right) is made of ½" thick plywood or MDO with 1x4" or 1x6" pine battens and 4x4" wooden skids.

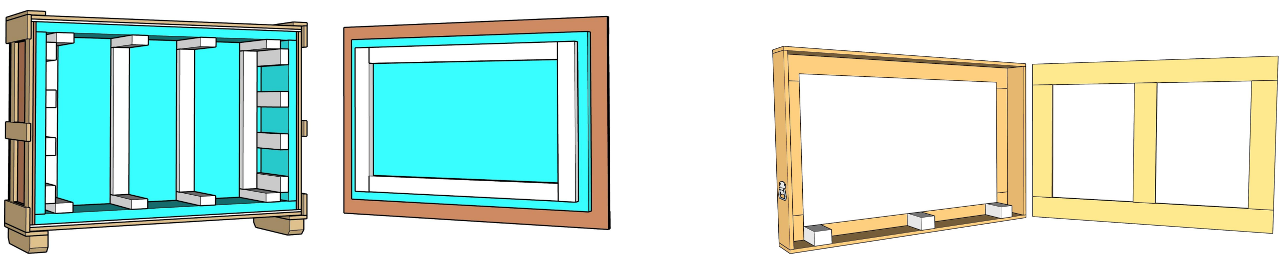


Figure 1. Object crates employ a variety of methods depending on the artwork being packed. In some cases, the inner box is filled with foam cut to the contours of the contents, as shown below.

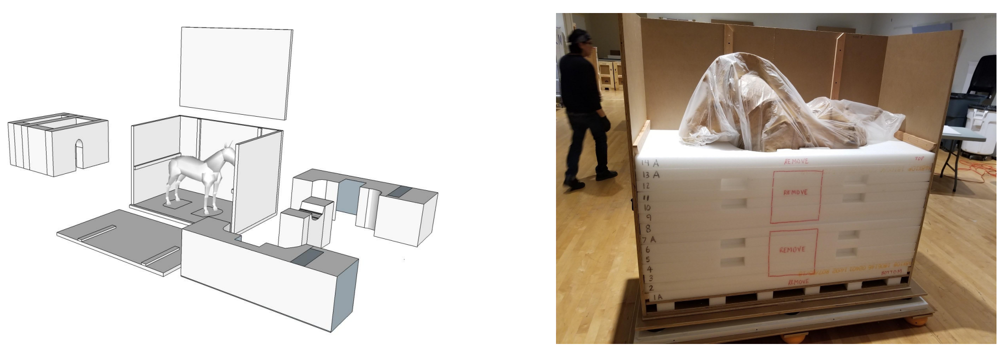


Figure 2. Haniwa Horse, 6th century BCE, LACMA, packing diagram with foam quantity and Haniwa Horse inner box, partially packed. Despite carving the foam to the contours of the sculpture and using vibration-absorbing viscoelastic polymer foam, the artwork broke where it had previously been repaired during transit to the National Gallery of Art in Washington, DC for the exhibition *Every Living Thing: Animals in Japanese Art* (2019).

Adopting new solutions for art packing presents challenges. Objects in museum collections vary greatly in size and shape, meaning crates cannot always be easily repurposed. Limited storage space at many museums leads to disposal of packing systems once shipping is completed, such as at the end of an exhibition tour. In the commercial gallery sector, one-way crates used to ship artwork between the artist or gallery and the collector are even more common, resulting in more waste. In the last decade, people from all sectors of the art world have called out the amount of waste produced by exhibitions—from gallery construction and temperature regulations in loan agreements to art shipping and packing materials. Two founders of the Sustainability Tools in Cultural Heritage or STiCH (a life cycle assessment Carbon

Calculator)[1], Sarah Nunberg and Sarah Sutton, deduced that if 10% of the 35,000 museums in the U.S. built 30 crates for just one exhibition annually, the number of crates built per year would total 105,000. Thirty crates is, however, a conservative number as in its last fiscal year, LACMA ordered 78 exhibition crates, 28 crates for outgoing loans, and built 49 crates in-house, for a total of 155 crates. In conducting market research of the art shipping industry, Andrew Stramentov, Founder and Managing Director of ROKBOX (a reusable crate company) and ROKBOX LOOP (a rental program for reusable crates), learned that a shipping partner with a 3-5% market share of fine art shipping builds 15,000–20,000 crates per year and discards 90% of them. Thus, estimates of the volume of crates built annually by the fine art shipping industry total 500,000 crates. Adoption of the guidelines developed by CRAIT would have a tremendous impact given the sheer volume of crates produced annually.

In 2020, LACMA's Collections Management and Art Preparation teams began searching for solutions to reduce, reuse, and recycle packing materials and decrease the volume of crates and packing materials being discarded each year. Then, in 2022, LACMA received a grant that allowed its Art Preparation and Conservation teams to launch a pilot program that tested ten packages containing three types of surrogate objects for shock and vibration mitigation in a package testing lab and measured their carbon footprints. This testing of cushioning systems compared typical packing methods and materials to plant-based foam, excelsior (shredded wood fiber), Hexcell wrap (an expanded paper product), wire rope isolators, and a ROKBOX reusable crate. The pilot program revealed that sustainable materials and reusable crates can be as effective or more effective than polyethylene foam at mitigating shock and vibration and made progress in finding ways to reuse and recycle single-use crate materials.[2] We presented the findings from the pilot program at PACCIN's (Preparation, Art Handling, Collections Care Information Network) Crating + Packing Sustainability Webinar in November 2023 and will present them at a pre-session called *Toward Art in Transit 2.0* at the American Institute for Conservation's annual convening in May 2024.

The CRAIT initiative will substantially expand on the pilot program to comprehensively test crate shell, insulation, and cushioning materials. Activities will include designing various packing systems, comparing their performance in transit, testing for chemicals such as acid and sulfur content, and conducting life cycle assessments to measure their carbon footprints. With the support of IMLS and by collaborating with and learning from colleagues, we believe we can find solutions that reduce the amount of harmful materials in art packaging, rely more on recyclable and compostable materials and reusable systems, and create guidelines that other institutions could use and adapt for their art shipping. Ultimately, CRAIT will develop new informed practices for packing art that protect both the art and the environment, while continuing to make art accessible to the public.

Target Group: For the pilot program and in preparation for this application, LACMA's team held workshops, meetings, and brainstorming sessions, and shared ideas through emails with colleagues from organizations across academic, museum, and shipping sectors, including the J. Paul Getty Museum, the Getty Conservation Institute (GCI), Hauser & Wirth, Art Institute of Chicago, National Gallery London, Cal Poly State University San Luis Obispo Industrial Technology and Packaging Program, WestPak Testing Services, Atelier 4 Fine Art Shipping, Crozier Fine Art Shipping, Dietl, Delaware National Art Company, ROKBOX, Leerform, STiCH, PACCIN, ICEFAT (International Convention of Exhibition and Fine Art), Ki Culture, Gallery Climate Coalition, and Rochester Institute of Technology's Image Permanence Institute (IPI). To date, 19 colleagues from 16 cross-sector organizations have committed to serving on the CRAIT advisory committee. Conservators, registrars, art shippers, packing designers and engineers, and material manufacturers contributed to the design of the CRAIT initiative. As detailed below, they will serve on an advisory committee to guide the work and provide feedback and subject-area expertise.

Museum professionals have a profound sense of responsibility around collection care, leading to the belief that we have a 0% acceptable loss rate for artwork in transit. However, the transportation of artwork always involves some risk, and transit does result in changes to artworks, as noted in the results of the "Vibratory Impacts of Music and Transport on Museum Collections" survey. Based on conversations with art handlers and conservators with decades of experience, most failures during transit happen because artworks were not properly packed, either because there is too much space around artworks, allowing movement during transit, because support was not applied in the strongest areas of an artwork, or the work was overpacked with protective materials. An optimal crate cushioning system should be determined using a

[1] STiCH earned a Tier I 2017-2019 NEH research grant awarded to The Foundation for the American Institute for Conservation (FAIC). In 2020 the project was awarded a Tier II NEH Research and Development Grant.
[2] See Supportingdoc2 for the report produced for the pilot program.

cushion curve calculator that factors the object's weight, fragility, density and type of foam, and the likely drop height of the package.[3] Few museums and art shipping companies use this tool, but its use can improve the efficiency and performance of a crate, reduce the amount of petroleum-based foam used, and reduce the cost of building crates. Loans arriving at LACMA are often packed with solid sheets of polyethylene foam (ethafoam) on all six sides of the crate, telling us the packer did not calculate the optimal amount of foam. Objects are over-cushioned and much more foam is used than necessary. Through an analysis of 24 crates for one LACMA exhibition, we found that the difference between using full sheets of foam on each side of the crate and calculating the optimal amount of foam led to a 75-80% reduction in foam used. By using a cushion curve calculator for a single exhibition, we saved about 141.5 cubic feet of foam. At 1.1366 KG of CO_2 per cubic foot of 2.2 lb/sf, that is 161 KG of CO_2, the equivalent of 18 gallons of gasoline consumed or 180 pounds of coal burned. Adoption of this tool by art packers would lead to a significant reduction in waste AND better protection for artwork. We plan to add this and other informed practices to the CRAIT publication to provide training and education for museum, gallery, and commercial art shipping professionals. We have also learned about vibration transmission curves in recent discussions with package engineers and will also explore how to incorporate this information into the design of our packing systems.

The publication will be designed for use by conservators, scientists, registrars, art handlers, art craters, and art shippers. The project's conclusions and the manual will be disseminated through professional associations such as PACCIN, Association of Registrars and Collection Specialists (ARCS), American Institute for Conservation (AIC), Foundation for Advancement in Conservation (FAIC), International Institute for Conservation of Historic and Artistic Works (IIC), ICEFAT, The Institute of Conservation (ICON); educational institutions such as Cal Poly University San Luis Obispo, Northeastern University, and the Rochester Institute of Technology; and environmental advocacy organizations like Ki Culture and Gallery Climate Coalition (GCC). This information will also be disseminated through LACMA's partnerships with international museums, such as Qatar Museums and Yuz Museum Shanghai, through formal networks of U.S. museums in which LACMA plays an active role, such as the Art Bridges Cohort Program, and through the Broad Museum's Diversity Apprenticeship Program which creates career opportunities in art handling and preparation and was initially funded by an IMLS National Leadership Grant.

Beneficiaries: Art packers and craters at museums, art shipping companies, and galleries will be able to use the CRAIT manual to design and build more sustainable packing systems for transporting artwork. The manual will close the gap between researchers and practitioners by providing guidelines in plain language for choosing materials; building, packing, and reusing crates; and reusing or recycling packing materials at the end of their life. Art handlers, conservators, registrars, and logistics personnel in general will also benefit from the project. Industry-wide adoption of these guidelines would significantly reduce the negative environmental impact of art packing, a benefit for all that contributes to addressing climate change and caring for our environment.

Benefits to the Field: The CRAIT initiative will provide immediate and long-term benefits to the museum field. In the short term, the initiative will develop and disseminate new art packing systems with low-emission materials, allowing museums to reduce waste from art packing and transportation. Additional, longer-term benefits will include raising awareness about existing research and tools for sustainable practices and strengthening industry networks for information sharing. Available tools like cushion curve calculators or STiCH's carbon calculator will be referenced in the CRAIT manual to ensure that those who choose and purchase materials and build and pack crates have the information they need to make informed decisions. We believe this will also encourage professionals in the field to consider and prioritize sustainable solutions, thereby protecting the environment as well as the artwork in transit.

The manual will be published online free of charge through a Creative Commons license, and research findings will be shared through conferences and with colleagues at museums, art galleries, and fine art shipping companies.

Existing Theory, Scholarship, and Practice: In 1991, several museum institutions came together to organize the first and only (to date) *Art in Transit* conference to address a significant conservation issue: the effect of travel on artwork. The conference focused on mitigating shock and vibration and the effects of temperature and humidity fluctuations on paintings in transit and explored packing materials that could mitigate these factors. The resulting publication, *Art in Transit: Studies in The Transport of Painting*, was published by the National Gallery of Art with the companion workbook

[3] The likely height that a crate might fall from given its size and mode of transportation.

Handbook for Packing and Transportation. Updated in 1997, it remains the standard within preventive conservation. The CRAIT initiative follows *Art in Transit*'s theoretical and practical approach but brings the information up to date and considers the need for more sustainable materials. The first part of the publication will include leading research on art in transit and the results of our tests. The second part will be a practical manual on effective crate design and material choices. Leading up to this application, the CRAIT team has already begun discussions with researchers studying the following areas, which will inform the art packing systems developed and tested during the project.

Effects of shock and vibration on artwork in transit: The Getty Conservation Institute's (GCI) Managing Collection Environments (MCE) initiative has conducted studies and amassed a considerable set of interior and exterior shock, vibration, temperature, and relative humidity data points for their crates during transit. While monitoring temperature and relative humidity is relatively common for museum crates, using accelerometers to assess shock and vibration is more limited. GCI tracks this data by placing accelerometers on the exterior of crates (including the truck floor) and near the object inside the crate to assess their performance in absorbing shock and dampening vibration. While the bulk of monitoring occurs when the crate is in a truck or airplane, special attention is given to the transitions between modes of transit, such as handling crates at the departure, intermediate junctions, and destination. These points in the journey pose vulnerable moments for risk and damage to the objects. CRAIT will build upon GCI's work, using the same methodologies to test packing systems but with more environmentally sustainable, lighter-weight (resulting in less fuel required for transporting), and less expensive materials. While GCI's studies have focused primarily on crates built at and for the J. Paul Getty Museum's Preparations Department, CRAIT will test a variety of packing systems available to all museums. LACMA has already collaborated with GCI to test several crates in transit and has connected the GCI team to other organizations to test their methods. GCI scientist Vincent Beltran and conservator Cecilia Winter also consulted on LACMA's pilot program. Related research on these factors include titles such as *Protecting Collections from Vibration During Transport*, by Verona Kotonski, Dr. Kerstin Kracht, Tim Waters, Evan York, and Thomas Hutchin at the British Museum; *Investigations into the Design, Configurations, and Performance Characteristics of Multi-Pack Lay-flat Pastel Crates* by Lynne Harrison and Mark Slattery at the National Gallery London, and *Vibratory Impacts of Music and Transport on Museum Collections* by Arne Johnson, Principal Structural Engineer at WJE Northbrook et al. The research from these authors will help inform CRAIT's package and test designs, and the performance data from these studies will be compared in the resulting manual.

*Effects of Temperature, Humidity, and Chemicals on Artwork in Transit***:** The Image Permanence Institute is in the final year of a three-year IMLS National Leadership Grant-funded research project that asks: What are the most cost-efficient and environmentally responsible methods of preparing paper-based collection objects for transit and display while maintaining preservation standards? This project, which focuses primarily on temperature and relative humidity, includes both field and laboratory research, and is the first research project to collect environmental data from multiple museums' shipping crates simultaneously. Laboratory experimentation includes testing the safety and relative humidity buffering capacity of crate packing materials and methods, and varied microenvironment sealed frame package designs used to protect objects during transit and display. IPI's work will feature prominently in the CRAIT manual, as the goals for their project are aligned with our project, and IPI Research Scientist Marvin Cummings will serve on the Advisory Committee. While IPI is focused exclusively on works on paper, CRAIT will study other object types, such as paintings and sculptures. Related research on these factors includes titles such as *Variations in Relative Humidity and Temperature as Measured in a Packing Case* by Nobuyuki Kamba, 1990; and *Monitoring the Environment within Packing Cases for Works of Art in Transit* by David Saunders and Richard Clarke, 1990.

*Carbon footprint measurement and sustainability***:** STiCH project team Dr. Matthew Eckelman, Sarah Nunberg, Sarah Sutton, and Sarah Sanchez developed a tool for calculating carbon emissions and demonstrated through case studies the activities related to exhibition development and production that generate the most carbon output. One case study *Crates for 3D Objects and Flat Work*, compares the carbon footprint of several styles of art packing crates. Using this tool to conduct life cycle assessments (LCAs), STiCH will help us to prioritize materials to test for performance and estimate the positive impact of replacing more traditional materials. They will then conduct LCAs of the final packing systems selected for testing. Private sector, for-profit companies have begun to integrate more sustainable art crates into their business model. For example, Justin Goldner, Managing Member at Delaware National Art Company (DNA), LLC, has developed Earthcrate—a crate that is 100% curbside recyclable. Crozier Fine Arts manages a crate reuse program for the National Gallery of Art in D.C. Commercial companies, including Turtle Crate and ROKBOX, have engineered and designed reusable crates for flat artworks, which are available for sale or lease through fine art shipping companies, including

Masterpiece International, Dietl, and Gander & White. We will test the performance of Earthcrate, ROKBOX, and Turtle products and include their benefits and challenges in the CRAIT manual. Representatives from STiCH, DNA, Crozier, ROKBOX, and Dietl will serve on the CRAIT advisory committee and share their expertise with us.

Advocacy for sustainable practices: Research and engagement on the topic of sustainability in the arts is growing exponentially, and the field has established organizations dedicated to advancing sustainable practices. Initiated in 2019, the [Gallery Climate Coalition] (GCC) launched its website as the art world's first open-source destination for sector-specific tools and free environmental guidelines on a range of topics. GCC memberships are quickly growing and include individuals, artists, museums, nonprofits, commercial galleries, and art service companies. Founded in 2020, Ki Culture is a global organization dedicated to creating actionable steps to make the cultural heritage field a leader toward a sustainable future. Ki Culture empowers individuals and institutions by offering partnership, guidance, effective solutions, and strategies. LACMA is an active member of GCC and GCC-LA, was part of the Ki Futures pilot program in 2021, and has participated in workshops, attended presentations by, and met with representatives from Ki Culture and GCC. CRAIT will benefit from the resources and guidance provided by these organizations and share results with them to help disseminate information that aligns with sustainability goals across the industry.

II. Project Work Plan

Activities and Sequence: The CRAIT initiative will be executed across three phases: development, testing and data collection, and publication and information sharing during a three-year period of performance, as outlined below and in the Schedule of Completion:

Year 1 (9/1/2024-8/31/2025)

- Assemble an **advisory committee** that includes: colleagues from institutions doing related research; colleagues from art shipping companies; engineers specializing in shock, vibration, and environmental testing; package designer/engineer; materials scientists. The advisory committee meets for a kick-off, helps gather current research and define testing parameters, and meets regularly throughout the grant period.
- Establish bi-weekly **project check-in meetings** with key staff.
- Hire a **scientist** who will gather and interpret existing data and literature and help process and disseminate the results of the CRAIT tests conducted. See job description included with key staff resumes. Recruitment and hiring will take place in the fall of 2024, with hiring and onboarding by February 2025.
- Establish quarterly **data management meetings** with IS, CRAIT Project Director, Head Scientist, and Scientist.
- **Design package systems**, purchase materials, build and pack up to 20 outer crates.
- STiCH conducts Life Cycle Assessments of all materials used
- **Laboratory testing begins** at the end of Year One; WestPak provides weekly updates.
- **Photo and video documentation** of package system design and testing is conducted.
- Assess project budget and write Year One report.

Year 2 (9/1/2025-8/31/2026)

- Research and data analysis continues through the first half of the year.
- Biweekly project check-in meetings continue.
- Advisory committee continues to meet quarterly.
- Data management team quarterly meetings continue.
- Round one crate testing is completed; **analyze and write reports** on round one test results.
- **Design round two package systems** and tests, purchase materials, and build and pack crates.
- STiCH conducts Life Cycle Assessments of all materials used
- Conduct round two testing and analyze data; WestPak provides weekly updates.
- **Photo and video documentation** of package system design and testing continues.
- Begin **aggregating and interpreting data** for publication.
- Determine the most promising packing systems and begin testing LACMA collection objects in transit.
- Assess project budget and write Year Two report.

Year 3 (9/1/2026-8/31/2027)

- Biweekly project check-in meetings continue with key staff.

- Advisory committee continues to meet quarterly.
- **Produce manual** of informed practices to share with the field that includes referenced research, and translates the aggregated data into a practical manual for packing that balances the risks to artwork and our environment. The manual will also include photos and illustrations of tests and package designs and a cushion curve calculator with instructions for use.
- Write the final report.

Potential Risks: Potential risks include the availability of sustainable alternatives to current packing materials, failure to hire a scientist due to mismatched expectations, timeline interruptions due to lab availability for testing, and failure of our field to adopt proposed changes. As manufacturing companies have developed sustainable options, lack of demand has caused some companies to stop production, or to only make materials available in prohibitively large quantities, or only to large fabricators. We plan to remain flexible in an effort to adapt and shift to new materials on the market. We will identify affordable materials that are available in manageable quantities. As far as field-wide adoption, we know that change can be hard, but we hope that by showing how many organizations are dedicated to combating climate change through practical solutions that still allow for public accessibility to artworks, by building trust across disciplines, and by using our platform as the largest encyclopedic museum in the western U.S., we can help facilitate that change.

Project Team: The CRAIT initiative will be managed by Julia Latané, Assistant Director in Art Preparation and Installation (API) at LACMA, who has over 25 years of experience in museums and galleries and a deep knowledge of materials, tools, and techniques for making, handling, packing, and moving art. As Assistant Director of Art Preparation at LACMA and co-author of the IMLS-funded Diversity Apprenticeship Program, Ms. Latané is well suited to oversee this project due to her professional background and commitment to the intersection of art, museums, and social justice. Project activities will be supported by a scientist, who will review and interpret existing research and data, oversee testing, track the data, and aggregate it into key findings. The scientist will be supervised by Laura Maccarelli, Andrew W. Mellon Head Scientist of LACMA's Conservation Research Lab. Michael Held, API Manager of Permanent Collections; Zach Trow, Senior Art Preparator; and Ms. Latané will design the packing systems to be tested, and build them with support from Johnny Medina, API Lead in Crating. Dr. Jay Singh, Professor and Director of the Packaging Program at the Orfalea College of Business, Cal Poly State University, San Luis Obispo, will assist the LACMA team with test design, and will also support the team as a consultant and advisor. Dr. William (Bill) Wei, Director of WEI Consulting, will consult on test design and interpreting data. Testing will take place at WestPak Testing Services in San Diego, which conducted testing for the pilot project.

The cross-sector Advisory Committee will include conservators, registrars, art shippers, packing designers, scientists, engineers, and material manufacturers. Advisors include authors of key studies and publications cited in this application (such as Vincent Beltran, Marvin Cummings, Matthew Eckelman, Catherine Higgitt, Sarah Nunberg, and David Saunders). To date, 19 colleagues have committed to serving on the Advisory Committee from the following organizations: Art Institute of Chicago, Cal Poly San Luis Obispo, Crozier, Dietl, GCI, Georgia O'Keeffe Museum, IPI, LACMA, Leerform, National Gallery London, PACCIN, ROKBOX, STiCH, WestPak, the Whitney Museum of Art, and White Cube Gallery. Advisors will help gather relevant research, provide guidance on packing system and test designs, review aggregated data, and share out results with colleagues, broadening the impact. Advisors may serve on working groups by area of specialization, such as crate design, test design, and data analysis and interpretation.

Resources Needed: The project will take place over a three-year period, and primary costs will involve the Scientist's salary, materials, testing, and travel. LACMA's crate shop will store packing materials and supplies and build interior boxes and crate shells made of multi-ply cardboard. Surrogate objects will be packed using LACMA's crate shop, and collection objects will be packed in a vault in collection storage. Crates will be stored in an offsite collection storage warehouse. The Scientist's workstation will be in the Science Laboratory at LACMA's Conservation Center. As detailed in the Budget Justification, the Scientist will be dedicated full-time to the project and will report to Head Scientist Laura Maccarelli; Julia Latane, Project Director, will devote 5% of her time to the project in the first year and 7% in years two and three; and additional key staff (Laura Maccarelli, Michael Held, and Zachary Trow, will devote 3-7% of their time to the project depending on the project phase. Administrative support will be provided by the Art Preparation and Installation Department's Program Administrator, and LACMA's Accounting and Development teams will track spending incurred by the grant activities and report on progress toward the project's objectives.

Tracking Progress: For this program to result in the widespread adoption of more sustainable packing methods, we need to be able to deliver current and accurate information and key findings to the people who order and build art packages in terms they understand. To accomplish this, the CRAIT program is designed to be inclusive, responsive, and iterative. The program staff, already deeply connected to others in their fields through publications, presentations, and membership or leadership in professional organizations, began building on those relationships and trust with colleagues in preparation for the pilot program in 2022 and have continued to grow their community of advisors in preparing for this proposal. Program staff will continue expanding the community and seeking information about new materials, new research results, gaps in research, and gaps in practitioner knowledge so that we can tailor the program tests and suggest informed practices for maximum results. Relevant information will be shared out as we learn, through meetings, workshops, emails, and conferences. The physical parts of the program, such as ordering materials and building and packing crates, will be tracked using the same project timeline, calendar, and budget ledger that we use to track our current exhibition, packing, and crating projects. Progress on the research-based parts of the program will be tracked with quarterly milestones and biweekly check-ins among program staff to maintain momentum and identify barriers to success early so we can pivot if necessary. As far as our impact on the environment, we will track the number of crates built and quantities of packing materials purchased each year and the corresponding carbon footprint in a spreadsheet and ask partner institutions to do the same.

Research Questions

A. **Can museums reduce their impact on the environment while still providing appropriate protection for artworks in transit?**
    - Which packing systems have the smallest environmental impact? Before finalizing crate designs and choosing material combinations, we will determine each proposed material's life cycle carbon footprint, from manufacturing to disposal.*
    - Can environmentally sustainable materials protect artwork from damage due to shock, vibration, temperature, and humidity as well as plywood, polyethylene foam, and styrofoam in packing systems?**
        - Can multi-ply corrugated cardboard or rigid paperboard replace plywood as a crate shell? *If* shock and vibration tests show that multi-ply corrugated cardboard or rigid paperboard provide equal or greater damping performance and climate chamber tests show they provide equal or greater temperature (T) and relative humidity (RH) mitigation performance than plywood boxes, *then* wooden boxes can be replaced with multiply corrugated or rigid paperboard boxes without increasing risk to artwork.
        - Can rock wool provide equal or better insulation for artwork from changes in T and RH than polystyrene foam (EPS)? *If* climate chamber tests show equal or greater insulation performance of rock wool over EPS, *then* EPS can be replaced with rock wool without increasing risk to artwork.
        - Can fiber flute or biofoam provide equal or greater cushioning against shock and vibration than polyethylene (PE) foam? *If* shock and vibration tests show that fiber flute and/or biofoam provide equal or greater damping performance than PE foam, *then* PE foam can be replaced with fiber flute or biofoam without increasing risk to artwork.
        - Are these materials safe for artworks in various media? Can we isolate the artwork with thin, reusable barrier films if acid or sulfur are present in the packing materials? *If* the materials off-gas chemicals that are harmful to certain objects and we can identify and test methods to isolate the artwork from the off-gassing within the package, *then* we should be able to safely use these materials in art shipping packages.

*The proposed list of materials may change based on product availability, current research, and innovation.
**Art crates are complex systems with multiple variables. Thus, testing will be conducted using many different configurations of packing materials. See supporting document #3 CRAIT test matrix for the proposed testing design.

Testable Hypothesis: *If* we can design and build package systems with more sustainable materials that perform as well in the mitigation of shock and vibration, and in reducing temperature and humidity fluctuations as crates made with plywood, polyethylene foam, and polystyrene foam, *then* we can significantly decrease the carbon footprint of packing and shipping art while maintaining the quality of care for art in transit.

Methods and Data:
As detailed in the Data Management Plan, we will test crate shells, inner boxes, insulation, and cushioning materials for shock and vibration transmission and temperature and humidity mitigation. All materials tested will undergo X-ray fluorescence, off-gassing, and microchemical testing to ensure their safety to artworks. Finally, cradle-to-grave Life Cycle Assessments will be performed on each material used in every packing system using STiCH's Carbon Calculator. Testing on surrogate objects will be conducted at an independent test laboratory specializing in product and package testing. Surrogate objects will include the same stretched canvas and cast concrete sculpture from the pilot program so that we can make accurate comparisons with our existing data. We will also test a piece of wooden furniture with removable parts, like a chest of drawers and multi-object crates containing fragile items to learn about the performance of more complex systems during transit.

Additionally, we will conduct real-transit tests on artworks from LACMA's collection, also detailed in the Data Management Plan, using packing systems that perform well in laboratory tests. These exhibitions or outgoing loan artworks will be selected in collaboration with the conservator, registrar, and curator based on their stability and suitability for the packing system. Packing systems will be tested over multi-leg journeys to simulate transport for traveling exhibitions.

Theoretical Framing: For generations, cultural heritage collections have been traveling from venue to venue for exhibitions, and while museums have been aware of the dangers that moving artwork present, only in the past few decades, with the development of modern technologies, has it been possible to study the effects of these dangers on collections in transit. The first effort to gather and present research on this topic was the 1991 Art in Transit conference in London and its consequent publication, which set new precedents in addressing the effects of travel on artwork, specifically paintings. The conference and publication focused on how to mitigate shock and vibration and the effect of fluctuating temperature and humidity and explored options for crate packing materials.

Since then, the fields of conservation and conservation science have developed tremendously, thanks to technological advances, and more studies have been conducted, giving us more conclusive information on the effects of transit on artworks. In 2014, Läuchli et al. published a paper during the ICOM-CC 17th Triennial Meeting in Melbourne focusing on the damping capacity of common packing systems, such as polyethylene foams (Ethafoam), flexible polyurethane foams, polyurethane composite foams and polystyrene (Styrofoam), all commonly used protective materials. This research was developed based on the previous findings from Bäschlin et al., 2011, which studied the damping capacity of backing boards and glazing on paintings.

In David Thickett's 2002 paper and Wei et al., 2014, further research revealed the effect of vibration on museum objects. In this research, recommendations are made for limits on allowable vibration during transit. At the same time that the museum field was studying shock and vibration effects on objects, the packing industry was also conducting similar research on packing materials, such as in Singh et al, 2005. In this study, the research focused on measuring and quantifying the levels of vibration that occur inside the package.

Thanks to the work done in recent years by both the museum field and packing industry, today we know more about cushioning curves, some of the effects of shock and vibration and temperature and humidity on artwork, and how to mitigate these, allowing us to expand the research and look into methods and materials that have not been broadly used to pack art before but have been used in the packing industry.

Relevance to Current Practice: In recent years, environmental sustainability has become an increasingly relevant topic across all sectors of our economy. The need to drastically reduce the carbon footprint of the global economy to reduce the disastrous effects of climate change is profound, to say the least, and one of our society's greatest challenges. One result of globalization has been the constant movement of materials and goods across the globe, and these practices have an enormous carbon footprint and, thus, a negative impact on our environment. For decades, the cultural heritage field has been shipping art globally, using non-recyclable, bulky, single-use materials.

The field recognizes the need for change, as evidenced by several projects that have been developed to assess and reduce its environmental impact. For example, as noted above, the American Institute for Conservation created the STiCH life cycle assessment calculator and other tools to help cultural heritage organizations reduce the environmental impact of their work. In Europe, the GReen ENdeavour in Art ResToration (GREENART) project aims to propose new solutions based on green and sustainable materials and methods to preserve and restore cultural heritage.[4] Nonprofits such as Ki Culture provide programs and tools to make culture sustainable, and leading organizations such as the Getty are studying greener alternatives for conservation materials and assessing whether strict temperature and relative humidity limits are necessary, which could substantially reduce energy consumption. By building on our limited pilot project, LACMA will collaborate with institutions across the US and Europe, build on what we learned in the first round of testing, contribute to this growing body of research, and ultimately change practices across the field.

IRB Approval: Our study does not involve human or animal subjects and thus does not require IRB approval.

III. Project Results

Resulting Models, Tools, and Research Findings: The CRAIT team will develop and publish a manual, available in print and online, to disseminate research methodologies and results, and will participate in international conferences to disseminate these findings. The manual will contain relevant research from conservation scientists aggregated with the data from CRAIT's iterative testing process, as well as practical information and illustrations of how to design and build art packing systems with more environmentally sustainable methods and materials that provide optimal protection for cultural heritage objects. In addition, a virtual workshop will be organized through PACCIN to teach others in the field sustainable practices for the use of these materials. The research will also be submitted for peer-reviewed papers in scientific and/or conservation journals. For further details, please refer to the Digital Product Plan.

Intended Results: The intended results of this project are to reduce the carbon footprint of packing (by reducing the quantity of materials and identifying more sustainable material options) and transporting (by reducing the weight of package systems) works of art and to do this while appropriately protecting those objects while they are in transit. The project will provide information about packing systems that are less harmful to the environment (including reusable systems and systems using curbside-recyclable and compostable materials), show how those systems perform in mitigating shock and vibration and changes in temperature and relative humidity, how to use cushion curves and other tools to inform efficient and effective packing practices, and how to design and build crates with alternative materials. The project has the potential to broadly benefit the museum and cultural heritage fields and society. From an educational and cultural perspective, allowing artworks to travel between institutions is important. This increases public accessibility to these works, often beyond major metropolitan areas and into communities with fewer cultural resources. However, without more sustainable practices, the museum field will be forced to severely limit the movement of objects as carbon footprint becomes more and more crucial to institutional priorities. The CRAIT initiative will benefit society by reducing carbon emissions, which will positively impact the negative trends of climate change and make cultural heritage objects more accessible by reducing the environmental dilemma posed by their transit.

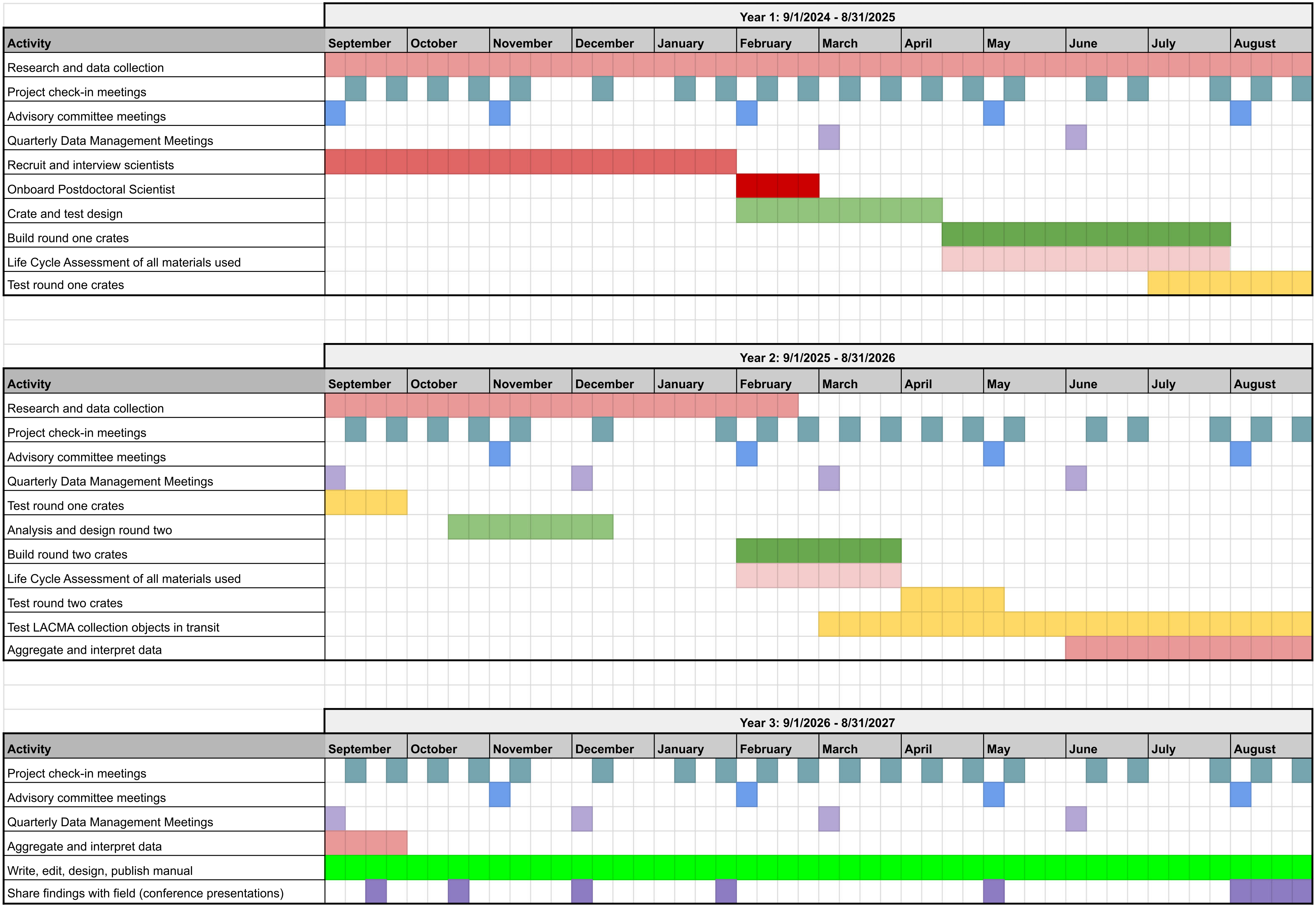
Changes to Target Group: Crate builders, art handlers, conservators, and registrars will have a data-based tool to refer to when designing, building, and packing crates. This will empower them to make affordable and better choices for the environment and the artwork. By gathering the work of colleagues, filling in the gaps in the existing research, identifying sustainable options for packing materials, and sharing the aggregated data interpreted into practical methods for packing artwork, we can provide the museum field with the knowledge it needs to care for the environment and our cultural heritage. If we can prove that more sustainable materials are just as or more effective and show successful use of these materials, we believe our peer institutions will adopt these practices to achieve their sustainability goals.

Sustaining Benefits: CRAIT proposes to bring together current research and fill in the gaps with new tests to get a holistic view of effective packing systems that optimally protect our cultural heritage and the environment. The impact of this project and the resulting manual will deepen as information is intentionally and proactively circulated across the museum field. As more and more people in the field are seeking ways to reduce their carbon footprint, this tool will be available to inform their choices. We will also aim to update the digital version of the manual with new materials as they are developed and tested, ensuring that the manual will not become obsolete as newer solutions are created.

[4] Three U.S. museums are serving as Associate Partners in the GREENART project: LACMA, the Metropolitan Museum in New York, and the Museum of Fine Arts, Houston.

Carbon Reduction and Art in Transit (CRAIT) LACMA

Schedule of Completion



Digital Products Plan

Type
The project will yield a manual of informed packing and crating practices that balance protecting the environment and cultural heritage objects. By compiling all current research that relates to issues around art in transit, including shock, vibration, temperature, humidity, and sustainability, and conducting comprehensive testing on surrogate and collection objects, we will pull out the common threads and translate the data into information that enables people to make better decisions about materials and their quantity when building and packing crates. Through this project, we will aim to expand the field's knowledge and acceptance of a range of materials for packing and crating.

Availability
The project team will widely disseminate a user-friendly manual and toolkit designed by and for museum professionals who are responsible for artwork transit. A limited number of copies will be available in a physical format, as the book's dissemination will take place largely online. The manual will be published as a downloadable PDF on LACMA's website, LACMA.org, and made freely available under a Creative Commons License CC BY-NC.

In addition to publishing the manual on LACMA's website, project findings will be shared with stakeholders, museum colleagues, and the general public via appropriate platforms. We will host training sessions, virtually and in-person, and work with our partners to ensure that the resulting information is widely available. Finally, the LACMA team and our partners will present at conferences and distribute information through listservs in their respective fields—PACCIN, ARCS, AIC, AAM, ICEFAT, and others.

Access
Users may download and use the content subject to the Terms and Conditions on LACMA.org and subject to any additional terms or restrictions applicable to the individual file or program, provided all copyright and other proprietary notices contained in the protected content are retained. Users must cite the authors and publication if used in further research.

Sustainability
The data and resources developed through this project will be preserved and maintained on LACMA's internal storage systems and various shared repositories and will be available for researchers upon request. LACMA maintains its own internal servers, which are backed up regularly to an offsite location. The database undergoes regular maintenance and upgrades as necessary.

Museum Associates dba Los Angeles County Museum of Art (LACMA)
Carbon Reduction for Art in Transit (CRAIT)

Performance Measure	**Data We Will Collect (e.g., counts, costs, weights, volumes, temperatures, percentages, hours, observations, opinions, feelings)**	**Source of Our Data (e.g., members of the target group, project staff, stakeholders, internal/ external documents, recording devices, databases)**	**Method We Will Use (e.g., survey, questionnaire, interview, focus group, informal discussion, observation, assessment, document analysis)**	**Schedule (e.g., daily, weekly, monthly, quarterly, annually, beginning/end)**
Effectiveness: The extent to which activities contribute to achieving the intended results	• At the end of each round of testing, WestPak Testing Services will provide data via a summative report that will be reviewed and analyzed by the project team and advisors. (A sample report is included in the Supplementary Materials.) • LACMA will work with STiCH to conduct Life Cycle Assessments of all tested materials. This data will be analyzed alongside the shock and vibration, temperature and humidity, and chemical test results at the end of each round of testing. • The CRAIT project team will present results quarterly to the advisory committee to ensure that we are generating data that will benefit a range of stakeholders.			
Efficiency: How well resources (e.g., funds, expertise, time) are used and costs are minimized while generating maximum value for the target group	• Twice per year, the CRAIT project director and LACMA's finance team will assess the project budget to ensure that all supply and equipment purchases and contractor fees are on target and that funds are being spent according to schedule. • Each quarter, the primary CRAIT team will provide hours worked on the project to LACMA's finance and grants administration teams.			
Quality: How well the activities meet the requirements and expectations of the target group	• During quarterly meetings, the advisory committee will be asked to provide input on the data collection and analysis and whether the results are useful to the field. The advisory committee will also provide input on newly developed materials and evolving field-wide needs.			
Timeliness: The extent to which each task/activity is completed within the proposed timeframe	• During regular biweekly meetings the CRAIT project team will review and track the project's progress and assess whether activity completion is aligned with the proposed Schedule of Completion. • Throughout both rounds of testing, WestPak will provide weekly updates to the CRAIT project team to ensure that testing is happening according to schedule.			

Data Management Plan

Type, Method, Scope, Scale, and Timeline

Crate design and building will begin in Year One, with testing beginning at the end of the first year. We will build or source up to 20 crate shells, including Earthcrates (100% curbside recyclable), reusable crates by RokBox and Turtle, multi-ply corrugated cardboard crates, and plywood crates. Inner boxes will be made of materials such as cardboard, rigid paperboard, MDO, and pine. Insulation materials may include EPS (styrofoam), foam core, and rock wool (mineral wool). Cushioning materials will include ethafoam, recycled ethafoam, plant or shell based foam, and fiber flute (fluted rigid paperboard). Material choices and tests may change depending on availability and the possible introduction of new materials. Surrogate objects inside the crates will include a cast concrete sculpture, a wooden chest of drawers, a stretched canvas, and a series of small, fragile objects packed together in the same crate. Testing will be conducted using many different configurations of packing materials, as detailed in the Test Matrix in the Supplemental Materials.

As materials are chosen, and the crates are designed, each variation of packing material will undergo three tests: 1) X-ray fluorescence testing will determine the elemental composition and ensure that brominated or chlorinated compounds are not present; 2) a small sample of the material will be put in a ziploc bag with an A-D strip for 2-3 weeks to detect any off-gassing; 3) a microchemical test will check for the presence of sulfur that could harm metal components.

Additionally, cradle-to-grave (tracking greenhouse gas emissions from source through manufacture through disposal) Life Cycle Assessments will be performed on each material used in every packing system by STiCH's Matthew Eckelman and Sarah Nunberg using their Carbon Calculator.

The first round of designing, building, and testing crates will take place during the second half of Year One, and the second round will begin mid-way through Year Two. In total, we will conduct 20-25 laboratory tests for shock and vibration transmission, 20-25 for temperature and humidity mitigation, and up to 20 chemical tests, as described below.

In the package testing lab, accelerometers will be attached to the objects and crates placed on a vibration table. The test will go through several "cycles" that will mimic truck or flight situations. The test design will be based on ISTA Procedure 3B, a general simulation test for packaged products shipped through a motor carrier (truck) delivery system, though we will start with the least potentially damaging tests and work up to those with the greatest potential for damage. After the vibration table, the objects will be visually assessed for damage, and their condition documented.

For shock performance assessment, crates will go through a series of drop tests, including rotational edge drop tests, where one side of the crate is propped up on a "kickstand" of a fixed height, which is then pulled out from underneath; topple tests, where crates are pushed over onto their face and side; and depending on the size of crate a fixed height drop test, where the crate is lifted off the floor to a specific height, and then dropped. Accelerometers will measure the G-forces experienced by the crate shell, inner box, and packed object. Data collected from vibration and shock tests will include resonant frequencies measured in Hertz, amplification levels as a multiplier of the input at resonance, and max transmitted deceleration levels as G-forces. After each test, the objects will be visually assessed for damage and their condition documented.

For temperature and relative humidity testing, crates will be placed in a chamber that will experience variations of low/high temperature and humidity. Sensors will record how the crate's interior responds relative to the climate chamber over time. Data from climate chamber tests is measured in degrees Celsius and percent relative humidity, as well as how long it takes (the rate of change) for the crate interior to reach the outside temperature and relative humidity when moved to a new environment. After each test, objects will be visually assessed for warping, cracking, or other damage, and their condition documented.

In the second half of Year Two, LACMA will utilize the most promising combination of crate shell, cushioning, and insulation materials to pack collection objects for actual shipments. In these in-transit assessments, monitors will be added to up to 15 shipping crates leaving LACMA to test their performance mitigating shock and vibration and changes in temperature and humidity while works are in transit. This would allow us to confirm the results of the lab test during in situ transit situations.

The data from all reports will be analyzed by the project team and advisory committee to draw conclusions on which packaging materials are best suited to provide safety and minimize damage to artwork in transit. Data on commonly used materials will be compared with that on newer, more sustainable materials, and the team will aim to determine the best combination of insulation, cushioning, and outer shell materials for packing various types of objects. The data resulting from LACMA's testing will also be compared with data shared by colleagues at The Getty Conservation Center, Image Permanence Institute, and National Gallery London, among others, to assemble a robust list of informed practices about a variety of object types and packing systems.

Intellectual Property
The test design does not involve collecting sensitive or confidential information.

Technical Hardware, Documentation and Storage
Laboratory testing on vibration, temperature, and relative humidity will be conducted by WestPak Package Testing, an independent test laboratory specializing in product and package testing, using Lansmont TP3 eight-channel shock and vibration recorders with triaxial accelerometers. Data will be provided to LACMA in summarized written PDF reports with photos and graphs for each packing system. Temperature and humidity data will be collected using HOBO Temperature/Relative Humidity (T/RH) data loggers. This data will be uploaded via Bluetooth by the LACMA Scientist from the HOBO loggers directly to a computer using a free app. Once collected, data will be saved in an Excel spreadsheet, and results will be captured in a written report using graphs to interpret the data.

Data from in-transit tests will be collected by LACMA's Scientist using Lansmont Saver (TM) 9X30 - Shock & Vibration Environment Recorders, Triaxial Accelerometers, and HOBO T/RH data loggers. The Lansmont Recorders come with Lansmont's SaverXwareTM software that allows the export of project data via USB cord to ASCII files and provides summary reports and user-defined project reports to document results. Data analysis features include GPS location, time, drop heights, impacts, vehicle motion, vibration, as well as temperature and humidity cycles. Data will be stored in Excel spreadsheets and compiled into written reports with graphs showing the performance of each packing system. Temperature and humidity data will be uploaded by the LACMA Scientist from the HOBO loggers directly to a computer using a free Bluetooth-enabled app. Once collected, data will be saved into an Excel spreadsheet, and results will be captured in a written report using graphs to interpret the data.

The Lansmont Saver unit's system requirements are Microsoft Windows® XP (SP3), Vista, 7 COM Interface: USB 1.1 or 2.0 compatible Data Rate: 400 kB/s (typical). The HOBO unit's system requirements are Windows 10, 11, Bluetooth 4.X and up.

All CRAIT research data will be gathered and stored on a LACMA internal server. In addition to the print version, the CRAIT Manual will be published online on LACMA's website under "Initiatives" for free, public access.

Management, Dissemination, and Preservation of Data
The Scientist who will be hired for this project will be responsible for gathering data, storing it, and processing it for LACMA. They will work with LACMA's Information Services department to find an appropriate, safe, and accessible location and protocols for storing data. The raw data from LACMA's testing will be provided to researchers upon request.

Review and Monitoring
As described in the Performance Measurement Plan, during regular biweekly meetings, the CRAIT project team will review and track the project's progress and assess whether activity completion is aligned with the proposed Schedule of Completion. Additionally, the CRAIT project team will present results quarterly to the advisory committee to ensure that we generate data that will benefit various stakeholders.