State Historical Museum of Iowa
Exhibit Gallery Lighting Planning Project

Project Director: Andrew Harrington

State Historical Society of Iowa

Submitted July 30, 2019
PROJECT GOAL
The goal of this planning project was to develop a sustainable exhibit lighting solution for the State Historical Museum of Iowa that balances the need for a more effective lighting design with cost and energy savings considerations along with preservation of artifacts and documents on exhibit.

BACKGROUND
The original and primary lighting system for the vast majority of the State Historical Museum’s gallery space (44,100 square feet) is still in use more than 30 years after the State Historical Building opened in 1987. The lighting system is comprised of theatrical/stage style spotlight fixtures attached to a system of metal pipes suspended from the concrete ceiling (Appendix 1). The fixtures in use are ellipsoidal variable focus spotlights that take 150w halogen bulbs, making them highly energy inefficient and inconsistent with present day best practices for sustainable museum lighting design. The halogen bulbs used in these fixtures have a variable lifespan and can last anywhere from 3-12 months before burning out. With approximately 560 fixtures between the two exhibit gallery levels, changing bulbs is a frequent, expensive and time-consuming task.

Furthermore, the Museum has limited control over how lights are turned on and off. The lights in the main exhibit galleries on levels one and two (approximately 22,000 square feet of exhibit gallery space per level) are controlled by just four light switches on each level and are turned on and off manually. There is no automation in place to precisely control how long the lights are on in the galleries each day.

Current light meter readings range from 16-180 lux in the galleries. For objects not behind acrylic glass, UV readings range from 30-110 microwatts per lumen, but are often higher than 75 microwatts per lumen. These light levels and UV levels can, at times, put high sensitivity and moderate sensitivity items on exhibit at risk. Without dimmers or occupancy sensors, light levels and exposure can be difficult to alter which at times necessitates premature removal of objects on display or not displaying certain items at all. Additionally, there are many areas in the galleries where more lighting would be beneficial for visitors when viewing objects and label text, and for navigating their way through the exhibit galleries. Currently, there are not enough light fixtures to adequately light both the exhibit elements (objects, text, and graphics) and pathways.
PROJECT ACTIVITIES
This planning project brought together a Project Team of consultants who worked collaboratively with each other and with a team of Museum, State of Iowa staff, and the Construction Manager to develop a plan for new energy-efficient lighting for the Museum galleries.

The Project Team included:

- Andrew Harrington, Exhibits Manager, Project Director, State Historical Museum of Iowa
- Katharine Coats, Collections Coordinator, State Historical Museum of Iowa
- David Raver, President, Trivalent Lighting Studio
- Chris Wojtal, Lighting Designer, Trivalent Lighting Studio
- Terry Healy, Principal/Lead Designer, HealyKohler Design
- Clint Paugh, former Director of Architectural Lighting, Henderson Engineers
- Jennifer Kleene, Owner's Representative, Iowa Dept. of Administrative Services
- Mark Nelson, Construction Manager, Ryan Companies

The lighting design and electrical engineering firm, Trivalent Lighting Studio (a subsidiary of MODUS Engineering), was the primary consultant with Terry Healy and Clint Paugh (museum lighting expert) serving in advisory roles.

Once notified of the grant award, Museum and State of Iowa staff gathered documentation and background materials for the rest of the Project Team to review. This included lighting data (UV and lux measurements) collected by Museum staff, along with exhibit gallery schematics and energy usage data. To kick off the planning project, the Project Director held an Orientation Meeting for the Project Team to share perspectives, areas of responsibilities, and review background materials. The Project Director then planned a one-day site visit to the Museum so the full team could tour the Museum galleries, review existing infrastructure, investigate existing power, circuiting and controls, and gain a more complete understanding of the shortcomings and challenges of the existing system. During these initial meetings, in-gallery exhibit lighting mock-ups were recommended by all consultants as an essential step in the process.

The next step was for Trivalent to begin to document the space and “test fit” lighting layouts by reviewing lighting needs and creating working drawings to be used as technical backgrounds as the design developed. A hierarchy of Museum lighting needs vs. wants was established with the help of a questionnaire developed by Trivalent in order to determine the lighting products to include in the mock-ups. The questionnaire asked the Museum staff to prioritize a variety of qualities to consider in a new lighting
system, including object preservation, energy savings, mounting options, fixture quality, lighting quality, and lighting equipment robustness and optional accessories. This exercise helped some of those most important qualities to rise in priority to the top of the list. For Museum staff these included preservation of objects (this was always the single most important criteria), museum grade fixtures, mounting system, color rendering, focusability, and dimmability. A schematic design for in-gallery mock-ups was developed by Trivalent and reviewed by the Project Team (Appendix 2).

The Project Team moved on to the mock-up phase. Trivalent first conducted virtual modeling in order to select manufacturers and verify that their optical distributions and lumen packages created the required outcomes desired by staff. The mock-ups were set-up as “head-to-head” demonstrations, lighting an empty 1,400 square foot space in the Museum so that staff could compare the performance in an exhibit gallery. This was a hands-on time for the consultants and the staff to work with the equipment from several different manufacturers in order to review fixture performance, ease of use, and construction. To make the mock-up as realistic as possible, Museum staff installed a mock exhibit in the gallery, including panel graphics and a variety of objects from the Museum’s collection (see Appendix 3 for completed mock-ups). When viewing the lighting mock-ups installed by Trivalent, the rest of the Project Team did not know which lights were which, other than knowing that one room of the gallery contained museum quality track and fixtures with integral LEDs and the other room had commodity level track and fixtures with replaceable lamps. Performance and operation of the equipment was reviewed under somewhat “blind” conditions so as to not influence anyone based on past history, colleague recommendations, or industry journals. In addition to the Project Team, the broader Museum team and collections staff were also able to explore the gallery and provide their feedback.

Once the Project Team and additional staff members viewed the mock-ups and discussed the pros and cons of the options on view, Museum Staff were able to identify a preferred manufacturer of museum-quality track and fixtures. Trivalent then created drawings and specifications documenting the quantities and selections of lighting fixtures selected during the mock-up.

Following the mock-ups and selection of preferred lighting, Trivalent moved forward with creating the design development (DD) drawings showing the proposed track layout throughout the Museum’s exhibit galleries (Appendix 4). The Project Team met again to review these drawings in detail. David Raver from Trivalent walked the team through the drawings, the integration of a new lighting system into the Museum’s existing electrical infrastructure, and a method to mount the light track to the existing pipe grid structures.
in the ceiling. This was an opportunity for the team to provide feedback, ask questions, and reach consensus on the path forward.

After the Project Team reviewed and approved the direction of the DD drawings, Trivalent moved forward with the production of the construction documents and drawings (CD). Per state guidelines, State of Iowa and Museum staff reviewed these design documents with Trivalent at 65% completion and at 95% completion during onsite visits and conference calls. Several rounds of review and comment took place on the construction drawings. Although taking longer than anticipated, this ensured all documents were accurate and contained all feedback provided by the team.

Once the CD documents reached completion (Appendix 5), accurate cost estimates were prepared and finalized by Trivalent and Ryan Companies in consultation with one another. This cost opinion will serve as a valuable document to the Museum as it strategizes its next steps for the eventual implementation of a new lighting system.

WORK PLAN

**August - October 2018**: Grant award received. Notify consultants and rest of Project Team. Consultant contracts executed. Orientation Meeting and Site Visit scheduled.

**October 2018**: Kickoff/Orientation Meeting for Project Team - review goals and scope of project, share perspectives, review responsibilities, and background materials.

**November 2018**: One-day Project Team Site Visit - tour the Museum galleries, review existing infrastructure, investigate existing power, circuiting and controls, and gain a more complete understanding of the shortcomings of the existing system.

**December 2018**: Schematic Design developed; Lighting options for mock-ups selected and ordered.

**January 2019 (actual: February 2019)**: Mock-ups installed and one-day Project Team visit to assess performance on-site in Museum gallery; viewing by broader Museum staff. Lighting selected for basis of design.

**February 2019 (actual: March 2019)**: Design Development Documents and Construction Documents completed and reviewed by Project Team.

IMPACT
This project was a critical first step to evaluate, select, and design a flexible, energy efficient exhibit lighting solution that will be safer for the collection objects and documents on display and provide an improved experience for visitors. Museum staff had basic ideas on how the lighting could be improved, but the broader team of experts was needed to examine the lighting options available and find a solution that works with our building and its infrastructure.

This project will have a dramatic impact on the State Historical Museum facility when the extensive planning that took place can be implemented through the installation of a new lighting system in the Museum galleries. The schematic documents, design development documents, and construction documents developed during this project form the road map for the future implementation of an upgraded lighting system for the Museum’s galleries.

When a new lighting system is implemented in the exhibit galleries, visitors to the Museum will have a greatly enhanced experience. This will lead to greater visitor comfort and enjoyment in the galleries by creating more evenly lit gallery spaces with museum-quality LED fixtures with high color rendering indices. It is anticipated that this will lead to longer dwell times in exhibits, improved readability of text and object viewing, an enhanced learning environment, and an increase in social interaction and information exchange between visitors. Improved light levels and distribution will also increase accessibility for visitors with visual impairments.

PROJECT CHANGES
The planning project took longer to complete than expected, but this did not impact the Project Team’s ability to complete the project’s objectives. One reason for the delay involved the mock-ups. While the sample materials and lighting fixtures were largely ordered in December 2018, Trivalent experienced delays in receiving all materials given the lead time required by some manufacturers and also due to the Christmas and New Year’s holidays.

In addition to delays during the mock-up stage, the Project Team experienced a greater number of rounds to review and comment on the construction drawings than anticipated. Additional time was taken towards the end of the project to ensure all documents were accurate and contained all feedback provided by the team.

Before beginning the planning project, Museum staff anticipated that doing exhibit lighting mock-ups would be important for the Project Team to view several fixtures and lamps first hand and how they perform in the gallery space. Anticipating that this could involve the purchase of a variety of fixtures and lamps, an additional $5,000 was
included in the budget for this purpose. Ultimately, Trivalent was able to arrange for a variety of lighting samples from different vendors to use in the mock-up at no cost. This is seen as a favorable development resulting in cost savings to the project.

In addition, Ryan Companies, the Construction Manager on the project, provided an estimate for their time on the project that was used to inform the original project budget. Actual time worked on the project turned out to be much less than Ryan Companies originally estimated, which resulted in additional savings of more than $9,000 on the project.

PROJECT OUTCOMES
The goals of this planning project were to identify a more sustainable exhibit lighting solution for the Museum’s exhibit galleries that balances an effective lighting design with cost and energy savings, improves preservation of objects and documents on exhibit by providing a safer display environment, and creates an improved experience for visitors. These goals were ultimately achieved by the Project Team during the course of the project.

Identifying a Lighting Solution
During the course of the in-gallery mock-ups the Project Team viewed a variety of fixture brands, types, and levels of quality (from a commodity-level $40 lamp to a $1,200 museum-quality motorized Bluetooth controlled fixture). The Project Team (and afterwards, the rest of the Museum staff) viewed a variety of available options and how they performed within a typical gallery environment in the Museum. David Raver from Trivalent explained to the team how the fixtures operated and the potential pros and cons of the various options. David also demonstrated how an evenly spaced track lighting system in the galleries with a larger quantity (and quality) of fixtures can help to provide more even lighting and three dimensional lighting (lighting objects from multiple angles). This is not possible with the current lighting system and quantity of fixtures. The clarity achieved in the objects on view during the mock-up, particularly under the museum-quality lighting, was far superior to the Museum’s existing lighting. This can be attributed to the qualities just mentioned and to the high color rendering index (CRI) of the lamps used.

After viewing the mock-ups and discussing the options available, the Project Team settled upon the track and integrated LED fixtures of Lighting Services, Inc. (LSI) as the preferred option to use as the basis for the lighting design moving forward. This was based on the quality of the lighting observed, fixture options available, the robustness of the products, ease of inserting and removing track heads, and reputation of the manufacturer. The longevity of the new lighting system is also of paramount importance to the Museum. The existing fixtures have been in place (in some instances) for more
than 30 years. Given the investment necessary to install a new lighting system throughout the galleries, it is necessary that it has a significant projected life span. The Project Team believes that a lighting system built around LSI track and fixtures will provide that longevity.

A More Sustainable Solution
Trivalent conducted an energy analysis of the Museum’s exhibit lighting based on existing energy rates and the lights being on for 60 hours per week (or 3,120 hours per year) in the galleries. Based on Trivalent’s recommendation, a selection of 940 LED fixtures from LSI were compared to the Museum’s existing 562 ellipsoidal spotlight fixtures which take 150 watt halogen lamps. The LED fixture wattages range from 5 watts to 31 watts. Even with a significant increase (378) in total number of fixtures, the estimated energy reduction compared to the existing fixtures is approximately 79% or 208,379 kilowatt hours. This will represent an annual cost savings to the Museum of $9,585 (Appendix 6). The Museum may see additional savings as staff plan to utilize dimmable fixtures.

The Museum typically replaces approximately 250 burned out halogen lamps per year at a cost of $575 total for the lamps and roughly 21 staff hours (at five minutes per lamp; this is inclusive of moving the personnel lift around the galleries and adjusting or re-aiming the fixture if needed). Given the extended lifespan of LED lamps, the savings impact will be even greater. The integrated LED modules in a new LSI lighting system would have a projected life of 50,000 hours (this is the expected time period for a lamp to reach 70% of its original output). Based on lighting the galleries for 3,120 hours per year, the LED lamps have the potential to have a 16 year lifespan. This would result in savings of $9,200 for replacement lamps and 336 staff hours over 16 years.

Improved Preservation
In addition to significantly lower energy usage, a much longer lifespan, and a better quality of light, switching to LED-based light sources from halogen will result in a safer display environment for the Historical Society’s collections. LED lamps do not contain harmful ultraviolet and infrared light that the current halogen lamps do. This will greatly reduce damage from these harmful parts of the light spectrum to the Museum’s most sensitive collection items, including paper, textile, and ethnographic objects. Although cumulative light damage can still occur with LED light sources over time, the risk is decreased.

Additionally, Museum staff will have greater control over the new lighting fixtures and will be able to dim the lights to appropriate levels and tailor the lighting to the types of objects on display. The light fixtures themselves will either have integral dimmers, or the
fixtures can accommodate filters or attachments, such as light blocking screens, that can alter the intensity and beam of the light. This will be a significant improvement over the existing light fixtures.

A new, modern exhibit lighting system will be integrated into the Museum’s existing building automation system (BAS), which will allow the staff to have greater control over the lights, including having them turn on and off each day at scheduled times. Additionally, the new lighting system will allow for the future inclusion of a multi-button control station that will give staff an even finer level of control over the lighting throughout the gallery spaces.

Improved Visitor Experience
This new lighting system will provide a dramatically improved visitor experience. This will be achieved, in part, by increasing the number and quality of fixtures throughout the exhibit galleries. By using the existing light pipe grids that occur regularly throughout the galleries, track fixtures will be suspended from this grid structure the entire length of the galleries from north to south and will occur every ten feet from east to west (Appendix 5). Having these continuous runs of track will allow Museum staff to provide much more evenly lit spaces and path lighting throughout the galleries. This will help to eliminate the constantly fluctuating light levels and areas of shadow that visitors currently experience. Additionally, sections of bridging track can be added perpendicular to continuous track runs to fulfill additional exhibit lighting needs as required (Appendix 4).

CONCLUSION
The support of a NEH Sustaining Cultural Heritage Collections Planning Grant was instrumental in allowing the State Historical Society of Iowa to bring together a multidisciplinary team to plan for a new exhibit lighting system. Through the extensive planning that took place, the project’s goals were met. Once implemented, a new LED track lighting system in the Museum will have a dramatic and positive impact on object preservation, visitor enjoyment, and energy savings.
APPENDICES
Appendix 1.
Existing Exhibit Lighting System used throughout majority of State Historical Museum of Iowa Exhibit Galleries (two ceiling views)
Appendix 1. continued
Spotlight Fixtures in Use at the State Historical Museum of Iowa
Lekolite ellipsoidal variable focus spotlight
Appendix 1. continued
Times Square ellipsoidal variable focus spotlight
Appendix 2. Lighting Mock-up drawings of a 1,400 sq ft exhibit gallery space in the Museum.
Appendix 2. continued

Intent: Compare new track lighting systems. Client review to include the following:
1) Comment on spacing and elevation of new tracks
2) Review of manufacturer specific heads and components
3) Begin to "inventory" quantity of spot, wash, various distributions, etc.

Manufacturers:
A) Lighting Services, Inc. (18" long 1-CCT line-track, bridge track and DMX control)
B) LyteLar (18" long 2-CCT track)
C) Edison Price (18" long 2-CCT track)
D) Leonia Brandt (12" long 1-CCT track + DMX + controls)

Products to be compared:
1) Spotlights (review various distributions, mounting, accessories, on-board controls)
2) Wash lights (review distributions and optics)
3) Specialty fixtures (framing projectors, very narrow optics, etc.)

Intent: Compare retrofit lamp and accessory options
1) Comment on needs for color tuning, effects and other speciality lighting
2) Review accessories and ability for interchanging them
3) Review specialty fixtures compared to track lighting systems

Manufacturers:
E) Ketra - Par38 and wash lights, remote control of color and intensity
F) Soraa - specialty lamps and optical accessories
G) ETC - theatrical effect fixtures and components
Appendix 2. continued
Appendix 3. Completed mock-ups

LIGHT LAB MOCK-UP FIXTURES
1) SPOT 1
2) SPOT 2 (not pictured)
3) SPOT 3 (not pictured)
4) SPOT 4
5) WASH 1
6) SPECIALTY

LIGHTING SERVICES, INC. MOCK-UP FIXTURES
1) SPOT 1
2) SPOT 2
3) SPOT 3
4) SPOT 4
5) WASH 1
6) SPECIALTY

EDISON PRICE MOCK-UP FIXTURES
1) SPOT 1
2) SPOT 2 (not pictured)
3) SPOT 3
4) WASH 1
5) SPECIALTY

STATE HISTORICAL MUSEUM OF IOWA
EXHIBIT GALLERY LIGHTING PROJECT
MOCK-UP
Appendix 3. continued

1. SPOT 1
2. SPOT 2
3. SPOT 3
4. SPOT 4 (not pictured)
5. WASH 1 (not pictured)
6. SPECIALTY
Appendix 3. continued

LIGHT LAB MOCK-UP FIXTURES
1) SPOT 1 (not pictured)
2) SPOT 2 (not pictured)
3) SPOT 3 (not pictured)
4) SPOT 4
5) WASH 1
6) SPECIALTY
Appendix 3. continued
MEASURED FOOT-CANDLE LEVEL ON OBJECT (AT CENTER)
Appendix 4.
Selection of Design Development drawings by Trivalent – View of first level galleries with proposed light track running north-south throughout space along existing pipe grid layout and detail view.
Appendix 4. continued
Views of proposed track mounting detail and bridge track application from Design Development drawings.
Appendix 5.
Selection of completed Construction Document (CD) drawings. The dashed squares represent the existing pipe grid system in the ceiling and the long solid lines represent the north-south continuous track runs.
Appendix 6.
Exhibit gallery lighting energy analysis by Trivalent

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**Total Savings:** 80.27 W

**% Reduction:** 83.4%

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**Total Savings:** 258,579.4 W

**% Reduction:** 79.7%