

Developing Library Strategy for 3D and Virtual Reality Collection Development and Reuse
Virginia Tech (VT), Indiana University (IU) and the University of Oklahoma (OU)

Abstract

A team led by Nathan Hall of Virginia Tech (VT), in collaboration with Jennifer Laherty of Indiana University (IU), and Matthew Cook of University of Oklahoma (OU) request \$95,024 with \$29,148 cost-share, to organize a series of three national forums. These forums will develop a roadmap and white paper for library adoption of Three Dimensional (3D) and Virtual Reality (VR) services to support new ways of interacting with digital content. The **intended audience** for this work includes administrators, imaging professionals, and VR project managers at academic libraries, public libraries, and technology-focused library consortia, as well as scientists, humanists, and artists who use 3D and VR applications in their research. The **timeframe** for this project is December 1, 2017 - November 30, 2018.

3D and VR technologies show great promise for a range of scholarly fields as they offer new potential for interactive visualization and analysis of artifacts, spaces, and data. Scientists for example can make more inferences from 3D digital models than from photos, while humanists can visually represent texts, images, and material artifacts in VR spaces to contextualize their relevance. Lower costs and greater computational power have made 3D and VR technologies financially realistic for a broader variety of institutions. As a result, sustainable programs and infrastructure for access and management of 3D and VR data are now vital. Many academic libraries have developed archives for other forms of research data, but there is an absence of standards and best practices for producing, managing, and preserving 3D and VR content. This gap is essentially an information management problem suited to the strengths of libraries.

We will convene a diverse team of researchers, practitioners, and other leaders in computer science, digital imaging, engineering, digital preservation, and digital libraries to participate in our National Forums to advance knowledge in archival and curation challenges in 3D/VR collections. Our **specific project activities** include organizing and hosting three national forums on different themes (Content Creation and Publishing, Visualization and Analysis, and Repository Practice and Standards) in different regional locales (Arlington, VA, Norman, OK, and Rosemont, IL). Core team staff with relevant experience from partner institutions will attend each forum along with expert practitioners, industry representatives, and those selected from a national call to participate. In order to keep forums a manageable size, each forum will have fifteen to twenty participants with expertise aligned with the specific forum theme, for a total maximum participation of sixty attendees. These participants will develop the roadmap and white paper for library adoption of 3D and VR services to support new ways of interacting with digital content, with recommended practices for in-house 3D/VR imaging programs including guidelines for production, cost-modeling, visualization, access, curation, and preservation for reuse. Participants will prepare for each forum with a common set of readings and case studies provided by the project team in advance, including the work of the previous forum(s) in the series in order to build upon a common context. Core team staff and an advisory board will develop a template with key questions for the forum to address. Each forum will follow an open space forum format focusing on specific questions pertinent to the forum themes to address the key outcomes for our white paper and roadmap. Follow-up work will include organization and synthesis of findings from the forums that will be published in established open access institutional repositories.

The forums will concentrate and advance knowledge and best practices for 3D and VR technologies in libraries. We will organize the white paper into sections corresponding with the forum themes described above. We will disseminate this document through relevant association listservs and high-impact conferences and journals for information professionals and disciplinary research scientists. The **intended outcomes** are to produce findings that allow libraries to strategically pursue 3D image and VR programs, and allow academic and public library users new ways of interacting with digital content.

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1.Statement of National Need

3D visualization and associated virtual reality (VR) technologies show great promise for a range of scholarly fields as they offer new potential for interactive engagement with and analysis of spatially complex artifacts, spaces, and data.ⁱ Just in the last three years, advances in computational hardware and lower costs have expanded the accessibility and practicality of using 3D and VR technologies in a range of research and educational contexts. Researchers and instructors in a range of fields are already incorporating 3D technologies into their scholarly practice in order to enhance their methods of analysis.^{ii,iii,iv,v} Scientists for example can make more inferences from 3D digital models than from photos, while humanists can visually represent texts, images, and material artifacts in VR spaces for detailed analysis and to better understand their cultural and historical context.^{vi,vii,viii,ix,x} Indeed, the great detail and high precision of 3D and VR-related data types encourages data reuse beyond the initial context of creation. For example, Chapman, et al. (2013)^{xi} discuss how the precision and accuracy of spatial data produced through 3D laser scanning enables future analytic possibilities for the 3D research dataset that the initial researchers may not foresee. Finally, 3D representation of fragile or otherwise inaccessible artifacts opens up access to a host of archived objects for a wider audience that includes undergraduates and the general public.^{xii}

While this new accessibility of emerging 3D/VR technologies presents new academic possibilities, new research infrastructures are required to effectively introduce 3D/VR into research and pedagogy. For example, the technical expertise to create, manage, and preserve these materials, as well as the visualization tools, access and preservation policies, and metadata schemas necessary to maintain their scholarly value. While many academic libraries have developed archives and policies for preserving and managing other forms of research data, and while museums have a long history of expertise in photographing artifacts^{xiii}, there is a notable absence of standards and best practices for producing, managing, and preserving 3D content and virtual reality environments. Specifically, more guidance is needed for broader integration of 3D/VR technologies into research and instructional practice with attention to issues such as hygiene and ergonomics of shared VR display hardware, sustainability of software, collaborative opportunities, space considerations, cost modeling, and personnel requirements. Finally, metadata schemas and recommended file formats are especially critical for supporting data reuse, reproducibility, and transparency in research applications of 3D/VR. In order to harness the transformative potential of 3D/VR applications to benefit interoperability, usability, and user community involvement of 3D/VR in U.S. libraries, library leaders need to understand the required combination of software applications, social and technical infrastructure, and staff expertise required to integrate 3D/VR technologies and collections into library services. Addressing this knowledge gap is of national significance and its resolution is suited to the strengths of libraries.

Establishing standards and best practices for 3D/VR is a nationally significant and timely issue. Academics are rapidly adopting these newly available technologies to enhance a variety of disciplines, from anatomy instruction to architectural visualization, but the knowledge infrastructure necessary to support the curation and preservation of 3D/VR is still noticeably lacking.^{xiv} 3D model creation often involves creating adhoc tools for collecting metadata, and metadata schemas are non-existent for many fields. The first wave of VR content from the 1990s is inaccessible because there was no preservation planning. There are no guidelines for ensuring that research results gained from using 3D visualizations are well-documented and reproducible.

¹ All cited works are in **Supportingdoc2.pdf**

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Writing nearly eight years ago, Koller, et al. (2009) already acknowledged the growing need for the establishment of centralized digital archives to support increasing trends in the creation of 3D models for 3D purposes, and identified the following challenges facing digital archives for these types of materials: “digital rights management for the 3D models, clear depiction of uncertainty in 3D reconstructions, version control for 3D models, effective metadata structures, long-term preservation, interoperability, and 3D searching” (p. 1).^{xv} It is therefore essential for academic libraries to quickly establish expertise in these areas as the use of 3D/VR continues to expand throughout the academy. As the crossroads of the university, the library divisions at many universities are already tasked with supporting data management planning for researchers. Therefore, academic libraries must take the lead in supporting these new scholarly processes enabled by 3D/VR technologies as they emerge, or risk losing an opportunity to influence the sustainability of a revolutionary technology.

This project supports the development of the **national digital platform** by enhancing the ability of libraries and archives to use open source technologies to provide digital content and services to all users in the United States. Our project achieves this by convening experts to develop guidelines that address a crucial issue for libraries, namely, how to support 3D modeling methods and tools for cutting edge work in digital sciences and digital humanities. The collaborative nature of this project draws upon expertise from multiple domains and sectors and benefits development of user community involvement in 3D/VR technologies. This project also allows the library community to meet user needs in 3D/VR content and the white paper and road map will provide a sustainable growth model for institutional infrastructure and capacity to support user adoption for 3D/VR services.

This project is unique because while researchers have used 3D and VR technologies as research tools for several decades, there have not yet been systematic attempts to develop best practices for 3D and VR. We build upon previous work in this area in a number of ways. In recent years, a handful of domain-specific research groups have attempted to develop 3D data creation workflows and repository structures (e.g., Doerr, et al., 2010; Doerr, et al., 2014) and metadata guidelines (e.g., Mourkoussis, et al., 2003; Patel, et al., 2005^{xvi}; and the Archaeology Data Service's Guide to Best Practices^{xvii}), and technical groups (e.g. the Khronos Group's COLLADA and OpenXR initiatives^{xviii}) have worked towards interoperability standards for 3D production software. Most recently, in May 2017 the European Union-funded PARTHENOS (Pooling Activities, Resources and Tools for Heritage E-research Networking, Optimization and Synergies) project issued a white paper^{xix} that outlined many of the challenges of developing standards in the areas of “production and processing of 3D objects,” “visualization and analysis,” “3D objects’ description with metadata and their long term preservation,” and “3D, cultural heritage and museology,” which they identified through a series of expert-led workshops held in Bordeaux, France in the fall 2016. While the PARTHENOS project seeks to address these challenges, their focus is primarily on arts and humanities research contexts, conceptualizing 3D models within “cultural heritage” paradigms of preservation, which leaves out scientific and other applications of 3D and VR that are of interest to a broad and growing body of researchers. It is clear that no national academic group in the US context has broached the interrelated issues of curation, preservation and display for 3D and VR. For this reason, there exists very little consensus concerning content creation workflows, metadata schemas, repository structure, and file formats for preservation.

This National Leadership Grant will fund three forums that will provide the ideal venue for experts from diverse research areas to meet and establish a set of guidelines that will help to support researchers and instructors as these technologies becoming increasingly common in academic contexts. Convened experts will be drawn from diverse domains, including libraries, museums, archives, non-profit organizations, foundations, and consortia, as well as from higher education, government, and the private sector. Stakeholders will bring

expertise in digital preservation, repositories, metadata schemas, intellectual property, information policy, and standardization initiatives, 3D/VR content creation, visualization, and analysis.

To summarize, this project will bring together experts to address the following ongoing challenges in scholarly applications of 3D/VR:

- Form holistic knowledge from normally siloed knowledge areas of 3D/VR by bringing together experts from a wide variety of disciplines, with expertise in different aspects of the research lifecycle (i.e. from across content creation, visualization and analysis, and repositories and preservation).
- Develop best practices to support 3D/VR throughout the research lifecycle (Limp, 2011; Alliez, 2017), including metadata schemas, workflows and tools for capturing metadata from content creation to visualization to archiving and reuse, and repositories that enable description, discovery, and long-term preservation.
- Establish guidelines that can serve multiple research contexts and use cases that libraries may need to support as researchers across disciplines begin to adopt 3D/VR as a research tool, and 3D/VR research data may become useful to multiple disciplines over time.
- Develop strategies that libraries can use for creating policies and workflows for providing 3D/VR related research services.

Individual faculty have already begun adopting 3D/VR tools due to their affordability as well as their usefulness in research, but no national group has determined how libraries - as centrally positioned information organizations - can best support this trend. By determining strategies and methods for the long-term sustainability of 3D/VR creation and visualization that both address common interdisciplinary concerns and accommodate domain-specific needs, we can better support these new scholarly practices that have already begun in earnest.

2. Project Design

We will convene a team of up to sixty researchers, practitioners, and other leaders in imaging science and engineering, digital preservation, and digital libraries to participate in our National Forums to advance knowledge in archival and curation challenges for 3D/VR collections. We will hold three national forums on different themes: Content Creation and Publishing (in Arlington, VA), Visualization and Analysis (in Norman, OK), and Repository Practice and Standards (in Rosemont, IL). In order to keep forums a manageable size, each forum will have fifteen-twenty participants with expertise aligned with the specific forum theme. The goals of this project are to develop a community of research and practice, hold a discussion, and begin to develop common practices for 3D imaging and virtual environments in libraries. The outcomes of our forums include a roadmap and white paper (See outline of white paper in **Supportingdoc3.pdf**) for library adoption of 3D and VR services to support new ways of interacting with digital content. Our assumption is that participants wish to agree on a common set of standards and practices for 3D digital objects and VR environments.

The project team and their respective institutions each bring vital expertise to the project. From Virginia Tech, **Nathan Hall** will serve as Project Director for the overall grant. He brings expertise in building and managing digital collections, supporting research data, development of inter-institutional data management policy, as well as experience in launching a 3D imaging program. He will coordinate efforts among all of the partners at Indiana University and the University of Oklahoma. Hall has strong experience in organizing and moderating forums and managing diverse institutional stakeholder groups and he is currently leading ACRL's development of a process for a new national research agenda for its research and scholarly environments initiative. **Andrea Ogier** is the Associate Director of Data Services at Virginia Tech University Libraries. Ogier provides expertise in designing data management and curation processes for digital objects in

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support of art, technology, science, humanities, and social science research projects. She will support the development and synthesis of findings from Forum A in Arlington, VA, with a focus on the uniqueness of 3D/VR objects and potential implications for use of open source, web scale, and proprietary asset management platforms. **Zhiwu Xie** is the Director of Digital Library Development at Virginia Tech Libraries. He brings expertise in digital preservation, big data, and library cyberinfrastructure research and development to the project. Xie has previously served as a PREMIS editorial committee member. He is a co-chair of Web Archiving and Digital Libraries (WADL) workshop series since 2015. Xie will support the development of research questions and the organization and synthesis of findings from Forum A in Arlington, VA. **Julie Speer** is the Associate Dean for Research and Informatics at Virginia Tech University Libraries. She brings expertise in the development of digital library services designed to provide preservation, visualization, and Open Access (OA) strategies for institutional and inter-institutional digital research, scholarship, and cultural heritage collections. She will support Project Director Hall with administrative duties of the overall grant and will manage local activities at Virginia Tech and Forum A in Arlington, VA, and will also support the synthesis of findings. Virginia Tech Libraries are widely recognized as leaders in library and information technology projects that facilitate access and public engagement, including leadership of ARL's SHARE program, code contributions to DSpace and Hydra open source software communities, IMLS-funded research in cyberinfrastructure to facilitate data sharing and reuse, open repository integrations with open science tools and institutional research information management systems, virtual collaboration platforms for arts communities, and open source digital curation workflow development for electronic theses and dissertations. Virginia Tech Libraries are deeply involved in national and international communities of leadership, practice, and knowledge sharing with regard to repository technology development, IT-Library collaboration, digital library research, digital preservation strategies, and shared service models and technologies. As co-host of the Open Repositories 2015 conference, Virginia Tech is prepared to handle the logistics of managing the forum.

From Indiana University, **Jennifer Laherty** will serve as Co-PI and Co-Director of the project at IU and supervise management tasks for the IU subcontract. This will include coordinating IU staff (Hardesty and Johnson) for implementing the Chicago based forum, working with all site Project PIs and Project Director on selection and invitation of forum attendees, and handling of the travel reimbursements for all attendees. She has participated in the international conversation, Physical Samples Digital Collections, at the Fall 2016 ASIS&T workshop in Copenhagen, Denmark. **Robert McDonald** will serve as Co-PI and Sr. Advisor on this award and will lead efforts in areas of cyberinfrastructure and commercial involvement in the forums and will lead the stakeholders advisory council for the project. McDonald has previously served as general co-chair for the ACM/IEEE Joint Conference on Digital Libraries in 2013 and 2017 and has been on the program planning committees as both member and chair for conferences such as Force 2017, HTRC UnCamp, Educause Annual Conference, Educause Mid-West Regional Conference, and the Educause Learning Initiative Conference. Previously he has also served as the Director of Community Development Kuali OLE. **Juliet Hardesty** will serve as Co-PI and will be a key advisor on areas of metadata for the project. She will work with IU lead Laherty on planning the Chicago meeting and coordinating efforts across the project with staff at Virginia Tech and the University of Oklahoma. Hardesty has experience in forums similar to those planned. She was an attendee at Always Already Computational: Collections as Data National Forum at University of California Santa Barbara in March 2017 and LD4P/LD4L-Labs Community Input forum in April 2017.^{xx} She has also served as facilitator for various working groups producing metadata recommendations within the open source Samvera Community (formerly Hydra Project).^{xxi} **Jennifer Johnson** is the Digital Scholarship Outreach Librarian at University Library, IUPUI. She will bring her expertise on 3D scanning to the overall project team and will assist IU team members Laherty and Hardesty in planning and coordinating the Chicago area forum. As an institution, University of Indiana is the ideal institution to host a forum on the development of 3D/VR repositories. IU Libraries have a

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long history of working with a diverse set of partners to build and develop open source software solutions for libraries. This includes work such as the Avalon Media System, the SEAD DataNet Repository Systems, the Kualu Open Library Environment, the VIVO Researcher Information System and the Variations Music Library. Working in partnership with other libraries, research centers, and discipline specific faculty members has become the norm for the IU Library System and they have made this capability an innate part of their library culture.

From University of Oklahoma, **Matthew Cook** will bring expertise to the Forum B areas of focus, including: downstream display and analysis of 3D assets in virtual reality using custom hardware and software implementations. Public-facing virtual reality workstations designed by Cook's team will allow for engagement with the tech and informal usability testing to spur further conversation on these topics. **Tara Carlisle** will provide assistance to Matt Cook in planning and carrying out the Forum B program at OU. Tara manages the Digital Scholarship Lab at OU Libraries and brings expertise in conceptualizing and coordinating collaborative projects in digital scholarship. She also contributes important experience coordinating multi-day, multi-participant scholarly events, including Research Bazaars and THAT Camps held at OU Libraries. **Zack Lischer-Katz** will provide assistance to Matt Cook in planning and carrying out the Forum B program at OU. Lischer-Katz brings expertise from his fellowship project, which is developing metadata guidelines and repository structures for managing and curating research data associated with virtual reality and 3D digital artifacts at OU Libraries. He also has experience planning academic conferences, including serving on the executive committee for the internationally-renown game/play studies conference, *Extending Play* (extendingplay.rutgers.edu) held at Rutgers University in spring 2015 and fall 2016. As an institution, University of Oklahoma has pioneered the development and deployment of public-facing virtual reality workstations, and the integration of these workstations into course curricula - across multiple colleges - as well as research agendas for faculty focused on spatial thinking and technology-assisted pedagogy. These efforts make them the ideal host and leader for a forum on the application of 3D/VR visualization and analysis tools in research and education.

Core team staff with relevant experience from partner institutions will attend each forum along with expert practitioners, industry representatives, and those selected from a national call to participate. This call will be passed along via national communication channels for library and information technology-centered audiences, such as the Coalition for Networked Information (CNI), Council on Library and Information Resources (CLIR), the Library and Information Technology Association (LITA), and Code4Lib. The core team staff has experience attending and managing multi-stakeholder meetings to gather input and produce recommendations and will lead each forum. The forums are being scheduled at dispersed locations across the United States (Virginia, Oklahoma, and Illinois) to accommodate the highest level of participation as well as core team staff locations. Participants at these forums will develop a roadmap and white paper for library adoption of 3D and VR services to support new ways of interacting with digital content. Participants will prepare in advance with a common set of readings and case studies (See list under the **National Forum Selected Pre-Readings** heading in **Supportingdoc2.pdf**). Core team staff and an advisory board will develop an agenda with key problems for the participants to address at each forum. Each forum will follow an open space meeting format^{xxii} focusing on specific questions pertinent to the forum themes to address the key outcomes for the white paper and roadmap (See outline of white paper in **Supportingdoc3.pdf**). Follow-up work will include organization and synthesis of findings from the forums to work towards the final white paper.

We have organized a diverse advisory board (see full list and their compiled CVs in Stakeholder Advisory Board in **Supportingdoc1.pdf**, and their letters of commitment in **Supportingdoc5.pdf**) to support the project's recruitment of participants and impact across disciplines and domains. **Dr. Clifford Lynch** is the Executive Director of the Coalition for Networked Information, a fellow of the American Association for the

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Advancement of Science and the National Information Standards Organization. A longtime leader in library technology trends, he served as co-chair of the National Academies Board on Research Data and Information from 2011-2016. **Ms. Diane Zorich** is Director of the Smithsonian Institution's Digitization Program Office, and therefore leads one of the world's most advanced 3D imaging programs. She and her team bring technical expertise as well as perspective from the museum field. **Dr. Patricia Hswe** is a Program Officer at the Mellon Foundation and incoming 2017-2018 Chair of ACRL's Research and Scholarly Environments Committee. She brings expertise in digital content strategy, digital preservation and curation in support of libraries, archives, museums, universities, and other cultural heritage institutions. **Dr. Margaret Dolinsky** is an Associate Professor of Art and Sr. Research Scientist at the Pervasive Technology Institute at Indiana University. She brings expertise in 3D computer graphic and CAVE development. Her own artwork concentrates on collaborative CAVE environments where two or more CAVEs are networked together using high-speed bandwidth of next-generation research networks. **Dr. Jerome McDonough** is an Associate Professor of Information Sciences at the University of Illinois at Urbana-Champaign. He brings expertise in digital libraries and digital preservation and curation where he has worked on projects that preserve virtual worlds. **Dr. Bryan Carter** is an Associate Professor of Africana Studies at the University of Arizona. His research focuses on advanced visualization and how sustained and varied digital communication affects student retention and engagement in literature courses taught both online and face-to-face. He has published numerous articles on his doctoral project, Virtual Harlem, which recreates the urban spaces of the Harlem Renaissance in virtual reality. **Mr. Carl Grant**, Associate Dean of Knowledge Services and Chief Technology Officer, University of Oklahoma Libraries, is former president (2008-2010) and chief librarian (2010-2011) of Ex Libris (USA), Inc., and is an internationally recognized lecturer on the topic of innovation in libraries. **Dr. Jason Jerald**, Co-Founder and Principal Consultant of NextGen Interaction, received his PhD in psychophysics from UNC Chapel-Hill before going on to publish numerous patents and peer-reviewed journal articles on the topic of virtual reality, including a monograph entitled *The VR Book: Human-Centered Design for Virtual Reality*. Moreover, Dr. Jerald has consulted with (or served on the board of) various technology companies, ranging from Valve, to NASA to Lockheed Martin. **Dr. W. Frederick Limp** is a Professor of Geosciences at University of Arkansas and former director (1991-2009) of the Center for Advanced Spatial Technology. He is an expert in informatics/geomatics and archaeology and heritage preservation. Since 1985 as PI or Co-PI he has received 217 extramural funding awards totalling \$38.6 million, which demonstrate his ability to administer and produce large interdisciplinary publicly-funded projects, to clearly articulate research problems and synthesize findings. This experience will benefit the final draft of the white paper.

To serve consensus building and to get buy-in from others in the field, we are also coordinating with a concurrently proposed IMLS NLG Forum Project entitled "Community standards for 3D data preservation (CS3DP)" led by Project Director **Jennifer Moore** (Moore, 2017) of Washington University in St. Louis. Moore will also serve on our stakeholder advisory board to ensure coordination between projects. We believe that this level of coordination will strengthen both projects. Our mutually shared goals in this collaboration are to complement without duplicating one another's efforts while also ensuring that our projects are sufficiently independent of each other, and not competing with each other. This allows our project to engage an existing community of practice for digital preservation with expertise and current work in the field. CS3DP will have formal representation at our forums and we will share our high level roadmap with this team as they explore more granular levels of 3D object preservation.

Risks for this project include lack of common ground, or adequate preparation by the participants. As stated above, we account for this by providing participants with common readings and case studies in advance of the forums (See list under the **National Forum Selected Pre-Readings** heading in **Supportingdoc2.pdf**). The

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core team staff and advisory board will also prepare a forum charge in advance and a template with key questions for each forum to address.

Forum Theme A: Content Creation and Publishing

Virginia Tech Research Center, Arlington, VA, March 2018

Hosting fifteen - twenty attendees, this forum will study 3D/VR digitization projects from public, private, and liberal arts institutions, as well as public libraries and library consortia. The open space meeting format of this forum will begin with a review of case studies, expert presentations, discussion of requirements. Attendees will brainstorm and analyze unique 3D and VR requirements as they relate to production and dissemination of objects, and will also discuss how to leverage free, web-based resources such as Open Science Framework and Figshare, as well as open source and vendor-supplied options for storage, access, and management. Metadata requirements for publishing and discovery will also be a focus. Discussion and voting will help clarify and consolidate ideas. This forum will also use collaborative and open documents and sketches to gather ideas for providing these services.

The outcomes of this forum include an overview of the skills, technology, labor, and other costs; workflows and metadata standards for content creation and publishing; best practices for preservation and access file formats; and implications for data curation best practices. The findings will inform the development of a roadmap for libraries and other institutions engaging in 3D/VR creation, digitization, and publication projects. Finally, the forum will discuss areas in need of further work.

Forum Theme B: Visualization and Analysis

University of Oklahoma, Norman, OK, June 2018

Hosting fifteen - twenty attendees, this forum will study integration of 3D/VR into teaching, research, and outreach. This open space forum will begin with a review of existing literature on the key topics and summary of findings from Forum A. Next, expert input will be solicited to identify key problems in the area. Finally, best practices and standards will be discussed and developed for a range of topics. Topics will include hardware and software design for establishing robust 3D/VR tools that provide scholarly access to 3D data produced via expert modeling techniques, workflows, and abstract or numerical data sets (e.g. weather data). Existing 3D/VR workstations developed by OU Libraries will provide a case study and launching point for discussion as well as the basis for informal usability testing during the meeting. Participants will also study interoperability of various 3D/VR platforms (mobile vs. web-based).

The intended outcomes of this forum are standards and practices for data preparation, metadata, workflows, and techniques to support 3D/VR visualization and analysis, as well as previously documented human-centered issues such as hygiene, ergonomics, and safety. The outcomes will also cover implications for data curation practices. The findings will inform the development of a road map for libraries to engage in 3D/VR visualization and analysis. Finally, the forum will discuss areas in need of further work.

To advance public outreach and impact, OU Libraries will also host a public forum immediately preceding the invitational IMLS-funded forum in which initial findings from Forum A can be presented to public forum attendees. The public forum will also include a focus group to identify challenges to implementing standards and best practices for smaller cultural heritage institutions. This will broaden our outreach as well as ensure that the findings are practicable for the needs of institutions with varying scales of funding and resources.

The format for the invitational forum meeting will include task-based testing of OU Libraries 3D/VR workstations and mobile and web-based 3D/VR platforms. The testing tasks will be based on feedback from the public forum and focus group and ideas for publishing requirements from Forum A.

Forum Theme C: Repository Practice and Standards

Big Ten Conference Center, Rosemont, IL, September 2018

Hosting fifteen - twenty attendees, this forum will study the feasibility to support 3D/VR within national preservation efforts such as APTrust and DPN, while closely examining the policies and practices of several strongly developed institutional repositories. National and international standards will inform the basis for best practices, including metadata requirements, storage policies, and curation workflows. This forum format will include expert presentations on industry standards for preservation and 3D viewers.^{xxiii} The case study and usability testing from Forum B and ideas for publishing requirements from Forum A will provide a basis to outline preservation requirements and policies for long-term management of 3D/VR objects.

The intended outcomes of this forum are standards and practices for general and domain-specific 3D/VR repository design, metadata standards for discoverability and preservation, interoperability standards, APIs, data curation workflows, and implications for existing digital preservation models and practices. The findings will inform the development of a road map for libraries to engage in the development and management of 3D/VR repositories. Finally, the forum will discuss areas in need of further work.

We will track progress toward achieving intended results through the Gantt chart in our Schedule of Completion (**Scheduleofcompletion.pdf**), and its prescribed deadlines for completing sections of the white paper prescribed in the Outline of Forum White Paper (**Supportingdoc3.pdf**).

To evaluate and measure performance we will collect data for all three forums by using an online survey to collect responses from each participant before (“pre-forum”) and after (“post-forum”) each forum meeting. Pre-forum survey questions will ask participants to provide their views on the current state of 3D/VR standards and best practices while Post-forum survey questions will ask participants to provide their views on their experience of the forum and the degree to which consensus has been reached regarding 3D/VR standards and best practices. We will analyze all survey data and summarize the findings associated with each forum in the corresponding section of the white paper.

3. National Impact

As a result of the three forums, the project will generate a set of agreed upon best practice guidelines for creation, visualization and analysis, and repositories and preservation for 3D/VR content, as well as strategies for related library policy and administration. Specifically, Forum A will produce guidelines that establish best practices for 3D/VR content creation and publishing; Forum B will develop guidelines that establish best practices for 3D/VR visualization and analysis; Forum C will develop guidelines that establish best practices for 3D/VR repository practices and standards, including metadata for discovery and preservation, data repository structures, and data curation workflows. The impact of these guidelines will be broad insofar as numerous previously siloed research areas working with 3D/VR will be brought together and their practices brought into consonance, with the results published in the white paper. The documented benefits of both virtual reality-based scholarship and digital 3D representation can then be systematically supported. Therefore, the forums effectively address current concerns surrounding burgeoning use of VR/3D technologies for scholarship by bringing together isolated and specialized stakeholders.

Thus far, efforts to consolidate standards and practices surrounding the use of these tools have been limited to specific departments or research programs. The task of curating and preserving 3D research data and related VR environments, and offering advice for researchers and instructors, therefore falls to the library because it is central to the knowledge infrastructure of the 21st century campus and deals with more disparate academic fields than any academic department. The common 3D/VR practices and standards produced through these forums will better equip libraries and their constituents to support knowledge production across the range of research areas.

3D/VR content is produced in a variety of ways. A simple architectural rendering produced by an undergraduate may not require the same level of processing and archiving that a grant-funded faculty research project demands, for example. The project will therefore seek to unify not only the the expertise of a

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range of subject specialists but also to provide a means for practitioners to differentiate between the analysis and preservation needs of academic end users, regardless of user status or sophistication. Essentially, the goal of the Forums is to provide an *overarching* framework that will encompass all levels of 3D/VR use within the academy while supporting a spectrum of users with standards, practices, and techniques useful for the preservation, curation, and display of increasingly prevalent 3D content.

The 3D digital asset’s usefulness does not end at the time of its creation. Therefore, the forums will also seek to synthesize knowledge from multiple stakeholder groups in order to develop an understanding of the *complete content lifecycle*, from creation - whether by photogrammetric, computational, or 3D modelling methods - to display and distribution. Downstream distribution of 3D assets, in particular, requires knowledge and experience of existing scholarly communication practices, and new technical knowledge of how to integrate these technologies into scholarly work (this includes understanding hardware, software, and ergonomic considerations, e.g. designing virtual reality workstations around the constraints of the human body and the intellectual needs of researchers).

To gauge the performance and success of the white paper outputs, we will track document downloads and citations in professional communities as well as impact on social media channels. Furthermore, we will measure success by tracking the expansion of the stakeholder community via the number of institutions adopting recommendations put forth within the white paper and journal articles. Specifically, we will use the following project targets and corresponding measures of success for the performance measures above:

Project performance targets	Measures of Success
Strong improvement in participant views on the degree which consensus has been reached for 3D/VR standards and best practices	<ul style="list-style-type: none"> • Analysis of pre-forum survey data and post-forum survey data.
Impact of the final white paper and roadmap.	<ul style="list-style-type: none"> • Number of document downloads from white paper and roadmap link in repository • Citations in professional communication channels • Retweets and other mentions in social media • Number of inbound links to the white paper and roadmap from authoritative and reputable external sites. • Number of institutions using recommendations of white paper after grant lifecycle
Improved communication between community of experts	<ul style="list-style-type: none"> • Adoption of project management communication tools by participants

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	and stakeholders during grant lifecycle
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The primary output of this IMLS Forum Grant project will be a white paper designed to establish best practices and standards for 3D/VR research and pedagogy. The white paper will provide guidance for academic librarians, researchers, and instructors who are seeking to integrate 3D/VR into some aspect of their research and instructional practice. The white paper will cover a range of issues, including commonly reported - but rarely anticipated - display-related hurdles associated with ergonomics (i.e. hardware and custom furniture design), hygiene, and sustainability (of software, for example). The white paper output will also comprise a “Library Implementation Roadmap” geared towards on-the-ground practitioners, which will detail collaborative opportunities, space considerations, personnel requirements, and more. Finally, metadata schemas and recommended file formats will be established and published for public comment via the white paper output, in the hopes of widespread adoption.

Beyond the primary white paper, the output will also take the form of journal articles, to be published in professional journals, with an audience of library and archives professionals in mind. These more technical documents will further synthesize conclusions drawn through the expert forums, especially with regards to the pedagogical impact of 3D/VR and published standards for metadata schemas and file format standardization, offering specific guidance for implementation by library professionals, including data curators, digital scholarship specialists, and emerging technology experts.

These forums contribute to the **National Digital Platform** by expanding digital capability and capacity of libraries across the U.S. through developing a high-level roadmap for use and integration of 3D and VR collections and technologies within the modern library eco-system (repository collection development, data management, data publishing, research and teaching). In order to improve sustainability and broaden the applicability of 3D and VR modeling tools, we are drawing our national forum participants from experts in digital technologies as well as cutting-edge scientists and humanists. Collectively, this team leverages and benefits from current best practices and future technology investments to create a roadmap for library engagement in 3D and VR development, collection, preservation, and use.



Our ultimate vision is to identify the required combination of software applications, social and technical infrastructure, and staff expertise required to integrate 3D/VR technologies and collections into library services, thereby improving interoperability, usability, and user community involvement in 3D/VR in U.S. libraries. Through our white paper and roadmap, our expert groups will make incremental, yet considerable progress towards that goal. The **potential impact** of these forums is to concentrate and advance knowledge and best practices for 3D and VR technologies in libraries. We will produce an open access white paper organized into sections corresponding with the forum themes described above. We will disseminate this document through relevant association listservs and high-impact conferences and journals for information professionals and disciplinary research scientists. The findings will allow libraries to strategically pursue 3D image and VR programs, and allow academic and public library users new ways of interacting with and preserving digital content.

Within the agency-level goal of Learning, we are addressing the **Support Communities of Practice performance goal**. Our forum will develop a white paper and roadmap that recommends practices for in-house 3D/VR imaging programs including production, cost modeling, visualization, access, and preservation for future use. All participants in our three regional expert meetings and select members of our dissemination presentations will take a Qualtrics survey in order for the team to gather quantitative user data outcomes of our learning-based community of practice.

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Schedule of Completion

Objectives		2017-2018			2018			2018			2018		
		Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov
1.0	Project Period												
1.1	Book venues for Meetings A, B, and C												
1.2	Recruit experts and stakeholder attendees for Meetings A, B, and C												
1.3	Design Preliminary Attendee Learning Surveys												
1.4	Design Follow-up Attendee Learning Surveys												
1.5	Develop readings and case studies for attendees												
2.0	Forum A												
2.1	1st Advisory Group meeting (online)												
2.2	Disseminate Preliminary Attendee Learning Survey												
2.3	Disseminate readings and case studies for Meeting A attendees												
2.4	Meeting A Convenes (Arlington, VA)												
2.5	Disseminate Follow-up learning survey												
2.6	Synthesize Meeting A outcomes												
3.0	Forum B												
3.1	2nd Advisory Group meeting (online)												
3.2	Disseminate Preliminary Attendee Learning Survey												
3.3	Disseminate readings and case studies for Meeting B attendees												
3.4	Meeting B Convenes (Norman, OK)												
3.5	Disseminate Follow-up learning survey												
3.6	Synthesize Meeting B outcomes												
4.0	Forum C												
4.1	3rd Advisory Group meeting (online)												
4.2	Disseminate Preliminary Attendee Learning Survey												
4.3	Disseminate readings and case studies for Meeting C attendees												
4.4	Meeting C Convenes (Rosemont, IL)												
4.5	Disseminate Follow-up learning survey												
4.6	Synthesize Meeting C outcomes												
5.0	Reporting												
5.1	Digital Library Federation Forum												
5.2	White paper and road map due to IMLS												
5.3	Final Report to IMLS (delivery date subject to IMLS announcement)												

 Projected dates for individual tasks
 Projected dates for category

DIGITAL PRODUCT FORM

Introduction

The Institute of Museum and Library Services (IMLS) is committed to expanding public access to federally funded digital products (i.e., digital content, resources, assets, software, and datasets). The products you create with IMLS funding require careful stewardship to protect and enhance their value, and they should be freely and readily available for use and re-use by libraries, archives, museums, and the public. However, applying these principles to the development and management of digital products can be challenging. Because technology is dynamic and because we do not want to inhibit innovation, we do not want to prescribe set standards and practices that could become quickly outdated. Instead, we ask that you answer questions that address specific aspects of creating and managing digital products. Like all components of your IMLS application, your answers will be used by IMLS staff and by expert peer reviewers to evaluate your application, and they will be important in determining whether your project will be funded.

Instructions

You must provide answers to the questions in Part I. In addition, you must also complete at least one of the subsequent sections. If you intend to create or collect digital content, resources, or assets, complete Part II. If you intend to develop software, complete Part III. If you intend to create a dataset, complete Part IV.

PART I: Intellectual Property Rights and Permissions

A.1 What will be the intellectual property status of the digital products (content, resources, assets, software, or datasets) you intend to create? Who will hold the copyright(s)? How will you explain property rights and permissions to potential users (for example, by assigning a non-restrictive license such as BSD, GNU, MIT, or Creative Commons to the product)? Explain and justify your licensing selections.

Intellectual property of any products will remain with the authors, in accordance with Virginia Tech University Policy 13000. We will explain terms of use with a Creative Commons license (Attribution 4.0 International). This selection is determined because ownership and control of research results is governed by Virginia Tech University Policy #13015 (<http://www.policies.vt.edu/13015.pdf>) which states that the project leader is expected to manage the university's ownership of research results and material in the ways that best advance the standard routes of dissemination for that particular field.

A.2 What ownership rights will your organization assert over the new digital products and what conditions will you impose on access and use? Explain and justify any terms of access and conditions of use and detail how you will notify potential users about relevant terms or conditions.

According to University Policy 13000 and 13015, Virginia Tech asserts its rights to the results of research funded in any part with university resources. Our white paper, which falls under Virginia Tech's category of traditional scholarship, is considered to make its full contribution to the university's benefit by its use in teaching, further development, and enhancement of the university's academic stature; the presumption of ownership is therefore with the author (<http://www.policies.vt.edu/13000.pdf> ; <http://www.policies.vt.edu/13015.pdf>).

A.3 If you will create any products that may involve privacy concerns, require obtaining permissions or rights, or raise any cultural sensitivities, describe the issues and how you plan to address them.

We will file applications with IRB offices at each institution involved. Survey data may include personally identifiable information based on the small sample size for each planned survey, but we will not be asking for sensitive information.

Part II: Projects Creating or Collecting Digital Content, Resources, or Assets

A. Creating or Collecting New Digital Content, Resources, or Assets

A.1 Describe the digital content, resources, or assets you will create or collect, the quantities of each type, and format you will use.

We will create one document (white paper and roadmap) in PDF/A-1a format. Survey data from six surveys will be archived in six separate files in CSV format.

A.2 List the equipment, software, and supplies that you will use to create the content, resources, or assets, or the name of the service provider that will perform the work.

Equipment will include desktop and laptop computers, tablets, and personal mobile devices. Software will include word processors, spreadsheets, and presentation software. Other resources will include collaborative cloud environments such as Google Team Drive.

A.3 List all the digital file formats (e.g., XML, TIFF, MPEG) you plan to use, along with the relevant information about the appropriate quality standards (e.g., resolution, sampling rate, or pixel dimensions).

We will primarily be working in the DOCX format, but final publication will be in PDF/A-1a to ensure broad accessibility.

B. Workflow and Asset Maintenance/Preservation

B.1 Describe your quality control plan (i.e., how you will monitor and evaluate your workflow and products).

Not applicable

B.2 Describe your plan for preserving and maintaining digital assets during and after the award period of performance. Your plan may address storage systems, shared repositories, technical documentation, migration planning, and commitment of organizational funding for these purposes. Please note: You may charge the federal award before closeout for the costs of publication or sharing of research results if the costs are not incurred during the period of performance of the federal award (see 2 C.F.R. § 200.461).

The final report will be stored in openly accessible institutional repositories at Virginia Tech, Indiana University, and University of Oklahoma with a Creative Commons Attribution License. Survey data will be stored in Virginia Tech's data repository (VTechData) with protection on files that require confidentiality. Files that do not require confidentiality will be made Open Access with a Creative Commons Attribution License.

C. Metadata

C.1 Describe how you will produce any and all technical, descriptive, administrative, or preservation metadata. Specify which standards you will use for the metadata structure (e.g., MARC, Dublin Core, Encoded Archival Description, PBCore, PREMIS) and metadata content (e.g., thesauri).

Documents and data archived in institutional repositories will use the Qualified Dublin Core standard in place at each institution.

C.2 Explain your strategy for preserving and maintaining metadata created or collected during and after the award period of performance.

Not applicable

C.3 Explain what metadata sharing and/or other strategies you will use to facilitate widespread discovery and use of the digital content, resources, or assets created during your project (e.g., an API [Application Programming Interface], contributions to a digital platform, or other ways you might enable batch queries and retrieval of metadata).

The repositories we have selected are OAI-PMH and OAI-ORE compliant. Furthermore, we will disseminate our white paper with the use of Twitter as well as announcements through professional listservs and forums such as CNI, ACRL, LITA, and CLIR

D. Access and Use

D.1 Describe how you will make the digital content, resources, or assets available to the public. Include details such as the delivery strategy (e.g., openly available online, available to specified audiences) and underlying hardware/software platforms and infrastructure (e.g., specific digital repository software or leased services, accessibility via standard web browsers, requirements for special software tools in order to use the content).

It will be openly available online in non-proprietary standard formats in repositories that do not require authentication, and in formats that are ADA compliant.

D.2 Provide the name(s) and URL(s) (Uniform Resource Locator) for any examples of previous digital content, resources, or assets your organization has created.

<https://vtechworks.lib.vt.edu> ; <https://data.lib.vt.edu> ; <https://shareok.org> ;
<https://scholarworks.iu.edu/dspace>

Part III. Projects Developing Software

A. General Information

A.1 Describe the software you intend to create, including a summary of the major functions it will perform and the intended primary audience(s) it will serve.

NA

A.2 List other existing software that wholly or partially performs the same functions, and explain how the software you intend to create is different, and justify why those differences are significant and necessary.

NA

B. Technical Information

B.1 List the programming languages, platforms, software, or other applications you will use to create your software and explain why you chose them.

NA

B.2 Describe how the software you intend to create will extend or interoperate with relevant existing software.

NA

B.3 Describe any underlying additional software or system dependencies necessary to run the software you intend to create.

NA

B.4 Describe the processes you will use for development, documentation, and for maintaining and updating documentation for users of the software.

NA

B.5 Provide the name(s) and URL(s) for examples of any previous software your organization has created.

NA

C. Access and Use

C.1 We expect applicants seeking federal funds for software to develop and release these products under open-source licenses to maximize access and promote reuse. What ownership rights will your organization assert over the software you intend to create, and what conditions will you impose on its access and use? Identify and explain the license under which you will release source code for the software you develop (e.g., BSD, GNU, or MIT software licenses). Explain and justify any prohibitive terms or conditions of use or access and detail how you will notify potential users about relevant terms and conditions.

NA

C.2 Describe how you will make the software and source code available to the public and/or its intended users.

NA

C.3 Identify where you will deposit the source code for the software you intend to develop:

Name of publicly accessible source code repository: NA

URL: NA

Part IV: Projects Creating Datasets

A.1 Identify the type of data you plan to collect or generate, and the purpose or intended use to which you expect it to be put. Describe the method(s) you will use and the approximate dates or intervals at which you will collect or generate it.

NA

A.2 Does the proposed data collection or research activity require approval by any internal review panel or institutional review board (IRB)? If so, has the proposed research activity been approved? If not, what is your plan for securing approval?

NA

A.3 Will you collect any personally identifiable information (PII), confidential information (e.g., trade secrets), or proprietary information? If so, detail the specific steps you will take to protect such information while you prepare the data files for public release (e.g., data anonymization, data suppression PII, or synthetic data).

NA

A.4 If you will collect additional documentation, such as consent agreements, along with the data, describe plans for preserving the documentation and ensuring that its relationship to the collected data is maintained.

NA

A.5 What methods will you use to collect or generate the data? Provide details about any technical requirements or dependencies that would be necessary for understanding, retrieving, displaying, or processing the dataset(s).

NA

A.6 What documentation (e.g., data documentation, codebooks) will you capture or create along with the dataset(s)? Where will the documentation be stored and in what format(s)? How will you permanently associate and manage the documentation with the dataset(s) it describes?

NA

A.7 What is your plan for archiving, managing, and disseminating data after the completion of the award-funded project?

NA

A.8 Identify where you will deposit the dataset(s):

Name of repository: NA

URL: NA

A.9 When and how frequently will you review this data management plan? How will the implementation be monitored?

NA