1. PROJECT JUSTIFICATION

This project fulfills IMLS National Leadership Grants for Libraries Goal 3 and objectives 3.1 and 3.3. The objectives of this project are to provide broad access to digital collections and maximize reach (Goal 3), particularly, to enhance digital infrastructure and platforms (3.1), and to support the design of accessible and usable digital libraries (DLs) to meet the needs of blind and visually impaired (BVI) users (3.3). Creating a new framework with the design guidelines specifically for developing DLs will support BVI users' access to information in mobile contexts. The University of Wisconsin-Milwaukee (UWM) requests $698,390 over three years. This project **builds upon UWM's prior IMLS-funded project** *Creating digital library DL design guidelines on accessibility, usability, and utility for BVI users* (LG-70-16-0038-16), which concluded in 2021. While that project focused on developing **desktop** DL accessibility and usability guidelines (dDLAUG) based on identifying help-seeking situations in BVI users' interaction with DLs, this project expands upon that work by creating **mobile** DL accessibility and usability guidelines **(**mDLAUG**).**

1.A The Need: Previous research and practice. In this project, a **BVI user** refers to a person without the sight necessary to see information presented on a display screen and who relies on screen-reader software to use information retrieval (IR) systems. The global BVI population exceeds 338 million [1], with 32.2 million residing in the U.S [2]. The percentage of BVI users who use mobile devices via screen readers has increased dramatically, from 12% in 2009 to 90% in 2021 [3]. BVI users represent an atypical group of users who depend on screen readers to interact with DLs. They face unique challenges in their interactions with DLs. To design DLs that meet the needs of BVI users, DL developers and scholars/experts must first understand their specific needs. **DL developers** create, design, and/or implement a DL, and **scholars/experts** study and/or test accessibility and usability issues of systems, including DLs. Based on search results from LinkedIn [4], about 3,400 registered professionals conduct DL-related work, and 44,000 and 98,000 professionals in the U.S. perform accessibility- and usability-related jobs, respectively. Moreover, according to Google Scholar [5], 970 and 875 scholars currently conduct accessibility and usability research, respectively.

BVI users exhibit unique help-seeking situations in Web interactions. A **help-seeking situation** is a problem that drives BVI users to seek help, either through help mechanisms/features of systems or human assistance, to facilitate their interactions and accomplish their tasks. Their difficulties during IR on mobile devices include issues related to applying gestures correctly, activating voice commands, using navigation elements, and compatibility issues with mobile devices and assistive technologies. Unfortunately, **BVI users experience more difficulties when using mobile devices than when using desktop computers**. Previous research on mobile devices found that BVI users could experience the same problems they encounter in the desktop environment, such as difficulty accessing images or multimedia content without alt-text, difficulty locating information, and difficulty understanding labels when using mobile devices [6-8]. BVI users also face unique problems due to the mobile interfaces of IR systems [9], including difficulty adapting new input methods in the mobile environment and using features when they need to use gestures on a smartphone's touchscreen [6, 10].

Researchers have investigated the issues associated with designing BVI-friendly **mobile platforms**. A **mobile app (M. App)**, developed for a specific operating system (OS), provides online content through its own interface rather than a web browser; users must download it on their mobile devices. On the other hand, a **mobile website (M. Web)** offers web content via a web browser on a mobile device through a responsive design that automatically supports multiple-screen resolutions or a mobile-dedicated design that supports a specific-screen resolution only [11-13]. In M. Web, keeping a desktop version of the layout in the mobile interface sometimes requires endless scrolling, and BVI users must listen to the complete list to access a relevant object [12]. Even though there are four primary mobile contexts (iOS phone, Android phone, iOS tablet, and Android tablet), **few studies have investigated and compared the difficulties that BVI users encounter during their interactions with the Internet in these mobile contexts** [14-16].

Accessibility and usability are critical research topics in developing IR systems for all users [12, 13, 17]. The World Wide Web Consortium (W3C) defines accessibility as "website, tools, and technologies designed and developed so that people with disabilities can use them" [18, Introduction to Web Accessibility section]. Usability is defined as "a quality attribute that assesses how easy user interfaces are to use" according to Nielsen [19, What — Definition of Usability section]. **Many researchers have investigated accessibility problems in the mobile environment** [8, 10, 13, 20]. For example, BVI users have issues accessing navigation mechanisms, features, and information/objects. First, as opposed to keyboard commands in the desktop environment, it is difficult for BVI users to navigate in the mobile environment when they have to touch and swipe on the screen [13, 21]. Inconsistent navigation layouts hinder their access to navigation mechanisms due to custom-made M. Apps created with different screen sizes and different online systems [21]. In addition, BVI users might lose their location due to unexpected interruptions from poor mobile interface design elements, such as floating action buttons in smartphones [22]. Second, accessing a feature in the mobile environment also causes problems to BVI users. Unlike in the desktop environment, the lack of a physical button on touchscreen devices

and issues with screen readers recognizing visual cues cause some accessibility issues [6, 10, 23]. For example, the lack of an always-available keyboard reduces BVI users' access to features (e.g., shortcuts) [21]. BVI users' difficulty locating features is due to improper or missing labels, while difficulty inferring the existence of functionalities is attributable to the inadequate feedback of controls, forms, and functionality [6, 8]. Lastly, accessing information objects may be worse in the mobile environment compared to the desktop environment. Even though the difficulty accessing images without alt-text exists in both desktop and mobile environments, the size of mobile devices forces all online system content to fit into the small screen by responsive design or mobile-dedicated design [6, 11-12, 20, 24].

In addition to accessibility problems, researchers have also studied **usability problems in the mobile environment**. Although most studies have investigated sighted users, some have concentrated on BVI users' issues in mobile contexts [9, 25]. First, BVI users have a long learning curve to interact with a smartphone's input method, which differs from the desktop version [10, 26]. In particular, BVI users have difficulty editing their previously entered text in the search box because they do not know how to check and modify their spelling errors without deleting all search terms [10, 27]. Second, BVI users' ease of use differs in diverse mobile contexts. For example, a simplified and blind-friendly M. App interface, such as the layout order and menu, reduces the cognitive overload of BVI users and increases ease of use [9, 13]. Third, the design difference in various mobile contexts also affects efficiency. Responsive designs create endless scrolling to present search results, causing BVI to experience very low efficiency [12, 28]. BVI users also have difficulty using a keyboard on mobile devices due to their different sizes and touchscreen, and they struggle to learn and complete tasks as efficiently as sighted users [10, 29]. Lastly, BVI users' satisfaction is affected by their perception of the design of an online system. If a system provides a mobile-friendly interface for BVI users, their satisfaction increases. For example, research shows that the adaptive features of an M. App for BVI users had a higher satisfaction score than the non-adaptive features of an M. App for BVI users [25].

The PI's research team conducted a series of studies to address these problems and has identified 17 help-seeking situations that BVI users experience when interacting with DLs in the desktop environment [30-32]. Recently, the PI **conducted a pilot study** (see Supportingdoc1), funded by a UWM Discovery and Innovation Grant, with 30 participants who performed three different types of tasks in the Library of Congress's Digital Collections, using its mobile web version and its M. App. This pilot study identified 33 help-seeking situations; about half occurred in the mobile environment but not in the desktop environment. The **top seven unique help-seeking situations** (see Supportingdoc2) include: for both M. Web and app, confusion about cluttered DL structure and layout and difficulty skimming search results; for M. Web only, difficulty distinguishing between a collection and item, difficulty finding a hidden feature, and difficulty identifying a relevant collection/item; for the M. App only, difficulty clearing a search box and difficulty finding explicit help. **These situations prevent BVI users from using sight-centered DLs as their information resources.**

In addition to expanding previous research, the project team will also **consider prior IMLS-awarded projects.** The current project builds upon our own successfully completed project developing dDLAUG (LG-70-16-0038-16) and the beneficial process of creating accessibility guidelines and standards for archives and art-centric digital archives for people with disabilities (LG-246431-OLS-20, LG-250072-OLS-21); integrating applicable practices of designing accessible websites implemented in the Taubman Museum of Art in Virginia (ARPML-250967-OMLS-22) and the Museum of Contemporary African Diasporan Arts (MoCADA) (MH-00-16-0019-16), as well as creating an accessible mobile application for museum collections by the Peabody Essex Museum (MG-10-14-0028-14).

1.B The Gap/Challenge: The lack of research and the limitations of existing guidelines. While the diverse formats of DL materials and complicated interfaces pose more challenges for BVI users**, no study (except the team's own pilot study) has addressed BVI users' use of DLs in mobile contexts.**

DL research has primarily focused on accessibility and usability [33-34], with the most commonly used guidelines focusing on Web accessibility [35]. The **accessibility of DLs is the primary requirement**, as BVI users need to access DLs and associated pages first. The problem is that these guidelines do not address many of the interaction problems and help-seeking situations BVI users specifically face in their use of DLs [36-38]. **Usability of DLs is the second requirement** because ease of understanding and ease of use are vital for BVI users to interact with DLs. Disabled users, particularly BVI users, experience not only accessibility problems but also usability problems [37, 39-40]. The most well-known guidelines produced for the Web Accessibility Initiative (WAI) under W3C, are the Web Content Accessibility Guidelines (WCAG), which is a technical standard for Web developers. Here are several of the critical issues that the WCAG 2.0 & 2.1 guidelines failed to present: 1) **some of the key unique problems and challenges faced by BVI users** and how to reduce the problems BVI users face [17, 37, 41-44], 2) **clear and specific instructions** for librarians who develop library websites for accessibility of disabled users due to vagueness and lack of specifications [44-45], and 3) guidelines **from a usability perspective** [39].

The PI's research team has created dDLAUG to support BVI users in the desktop environment based on identifying help-seeking situations funded by the previous IMLS National Leadership Grant. During the user study, we noticed that BVI users frequently used mobile devices to seek information. However, research indicates that applications are inaccessible due to the lack of adherence to mobile accessibility guidelines [46]. WAI developed the most popular guidelines, WCAG 2.0 and Mobile Web Best Practices, to make the Web more accessible to users with disabilities in the mobile context [47]. WCAG 2.0 can be applied to M. Web, M. App, native apps, and hybrid apps using web components inside native apps [48], and WCAG 2.1 [49] added new requirements (e.g., "success criteria") for mobile accessibility. Several researchers have also created heuristics or design guidelines that could be used to test the accessibility of smartphones [50-54]. Google and Apple have also established their mobile accessibility guidelines. However, while several guidelines exist, these guidelines are generally focused on mobile applications and interactions with the Web. Nevertheless, **the three problems of WCAG noted above for the desktop environment also exist in the mobile environment mainly because WCAG, and related guidelines or heuristics, primarily focus on accessibility issues but do not consider usability issues.** Most importantly, **existing mobile guidelines have not considered the complexity of DL structure, content, and information searching and their impact on BVI users in mobile contexts**.

1.C The Solution. DLs are increasingly becoming the preferred resource for searchers, supplementing physical interactions with traditional libraries. Simultaneously, more and more BVI users access and use DLs via their mobile devices. The proposed project innovatively addresses the issue of mobile DL accessibility and usability for one of the key underserved groups by creating design guidelines to address BVI users' help-seeking situations. As previously discussed, it is difficult for BVI users to adapt to different types of DLs. Existing design guidelines that do not holistically address these problems result in poor DL design and thus hinder BVI users' ability to use DLs effectively. Existing guidelines must be assessed for gaps, and new guidelines must be developed to make mobile DLs accessible and usable useful. None of the research has addressed building guidelines for mobile DL design that support BVI users' accessibility and usability needs. The proposed research will impact DLs across the country by filling these gaps and ensuring that DLs meet the needs of diverse communities.

This innovative project addresses the issue of mobile DL accessibility and usability for BVI users by creating a new framework for designing DLs, particularly the development of mDLAUG to address BVI users' help-seeking situations in the mobile environment. When such problems, or "help-seeking situations," arise, BVI users seek assistance to complete their IR tasks. Since BVI users have unique needs, challenges, strategies, and preferences in their interactions with DLs, especially when using mobile devices, this project focuses on those BVI users who cannot see information presented on a display screen and thus rely on screen-reader software to interact with DLs. To offer accessible and usable DLs to BVI users, DL developers need to have design knowledge that considers BVI users' unique help-seeking situations and help needs. Previous research has identified diverse types of help-seeking situations when BVI users use mobile devices, but not within DLs.

The project will address research questions concerning limitations of existing design guidelines, unique help-seeking situations that BVI users encounter in mobile DL contexts, types of needed design guidelines, the perspectives of key DL stakeholders on mDLAUG, the status of DL design in compliance with mDLAUG, and the challenges that developers face in implementing mDLAUG and associated solutions. Results from this project will inform DL researchers and practitioners about the impact of DL design problems on BVI users and enable DL developers to enhance DLs for universal access, thereby increasing BVI users' access to and use of DLs in the mobile environment. The results can also assist in generating guidelines for non-BVI users, such as people with other types of disabilities and the elderly. This project can serve as a model for developing design guidelines for different user groups in diverse library/museum digital platforms, and the design guidelines can be implemented in systems such as web search engines, online databases, and online public access catalogs. The project team will submit the guidelines to W3C and other organizations for adoption. As external environments and related technologies change continuously, the PI plans to conduct future studies to ensure guidelines remain relevant to support BVI users.

2. PROJECT WORK PLAN (August 2022-July 2025)
2.A Personnel. To ensure the success and sustainability of the project, the project team will work with consultants, advisory board members, and partners representing different DL stakeholders to develop, promote, and implement mDLAUG. The team members are leading experts in various cross-disciplinary fields, such as DLs, BVI users, mobile interface design, usability, web accessibility, guideline creation, implementation and evaluation, and partners representing multiple DL stakeholders. Consultants, advisory board members, and partners will also engage in ongoing dialogues on the project through the mDLAUG Forum created for the project (See Projectstaff.pdf and Resumes.pdf for a list of key

personnel and their resumes, and **Supportingdoc3.pdf for letters of support from consultants, board members, and partners)**. Specific roles of each consultant, board member, and partner are explained in their letters.

  Principal Investigator and Project Director: Dr. Iris Xie will oversee and manage the project. Dr. Xie has been actively involved in DL research for about 20 years and help-seeking for sighted and BVI users for more than 15 years. Her research interests and expertise focus on DL design and evaluation, interactive IR, usability, and user studies. Her research is highlighted in her two books, "*Interactive Information Retrieval in Digital Environments*" and "*Discover Digital Libraries: Theory and practice*." Her DL-related projects range from the IMLS funded project "Creating digital library DL design guidelines on accessibility, usability, and utility for BVI users;" the NSF funded project "Creation of the Internet Research Ethics Digital Library;" to the OCLC/ALISE grant "Universal Accessibility of Digital Libraries: Design of help mechanisms for blind users." She has served on the ASIST standards committee for several years. This project is a natural progression in the active focus of Dr. Xie's research. The **Co-PI, Dr. Wonchan Choi'**s research focuses on the user's effective use of information systems and services on web and mobile platforms to fulfill needs in different contexts. He has substantial research experience with mobile applications design and expertise in user studies investigating their needs, behaviors, and experiences in mobile contexts. Both PIs will work on every activity of the project. **Doctoral students Tae Hee Lee, Shengang Wang, Hyun Seung Lee, and Meredith Sabar** will work on the project as research assistants and/or hourly help.

  Consultants will analyze existing DL design guidelines; help identify problems found through the user study but not addressed by existing guidelines; assist in the creation of mDLAUG and provide ongoing feedback at various stages; give feedback on the instruments designed for the assessment of leading DLs; and assist the team to promote and implement mDLAUG, working with different partners and organizations. **Consultant Dr. Rakesh Babu** is blind and has a strong motivation to undertake research to empower the BVI in the information society. Dr. Babu has conducted research on accessibility and usability for BVI users for approximately ten years. His research expertise includes systems accessibility and usability, user-centered design, and evaluation. He has conducted research projects sponsored by agencies such as NSF, IMLS, the European Research Council, and OCLC/ALISE. He was also a Co-PI for the previous IMLS project. **Consultant Dr. James Allan** was the chair of the W3C User Agent Accessibility Guidelines Working Group (UAWG) and has involved in the Web Accessibility Initiative (WAI) since 1997. His expertise includes accessibility guidelines creation, implementation, and evaluation. **Consultant Dr. Krystyna Matusiak**'s expertise covers DL development, evaluation, and usability. Dr. Matusiak worked as a Digital Librarian for ten years and designed over 20 distinct digital collections. She chairs the ASIST Special Interest Group for Visualization, Images, and Sound.

  Advisory board members will provide feedback on products generated in all stages, offer general guidance on project activities, and help the project research team implement and promote mDLAUG. Our advisory board members consist of experts from BVI- and DL-related organizations and scholars who have expertise in relevant research areas. *Lou Ann Blake* (Director of Research Programs**, National Federation of the Blind)**, and *Mary Alexander* (Senior Director, Vocational Rehabilitation and Programs and the College Success Program, **Envision)** are from BVI-related organizations. They both have extensive experience of working with BVI people and understand their needs. Multiple advisory board members work in DL-related organizations, including *Michael Della Bitta* (Director of Technology**, Digital Public Library of America**), *Michelle Brennan* (Product Manager**, OER Commons**), *Shane Huddleston* (Product Manager, **CONTENTdm**, **OCLC**), *Jennifer Ferretti* (Senior Program Officer, **Digital Library Federation**), *Mike Furlough* (Executive Director, **HathiTrust**), *Beret Balestrieri Kohn* (Manager of Digital Assets**, Milwaukee Art Museum**), *Shaneé Yvette Murrain* (Director of Community Engagement, **Digital Public Library of America**), *Serena Rosenhan* (Vice President**,** User Experience Design, **ProQuest**). They have relevant expertise in helping create, assess, and promote DLs for universal access. Three scholars with relevant expertise are *Jonathan Lazar* **(Director of Trace R&D, University of Maryland)**, *Bengisu Tulu* (Professor, **Worcester Polytechnic Institute**), and *Marcia Zeng* (Professor, **Kent State University**). **Professor Lazar** has extensive research experience in accessibility and usability and is **leading Trace R&D**, which conducts research on and development of technologies for vulnerable people. **Professor Tulu** specializes in information technologies and **mobile designs**. **Professor Zeng** has served on **IFLA's DL Guidelines Working Group,** and her expertise is in linked data, metadata, and digital humanities.

  Partners will provide feedback and consultation throughout the project, as well as assist with participant recruiting, implementing products in real settings, disseminating and promoting the resulting products. The project has received support from and will partner with several national and regional associations and organizations. **BVI partner organizations and accessibility partners** include the American Council of the Blind, the American Foundation for the Blind, and the Vision Forward Association. **Associations** include the Digital Library Federation. **Library and Museum partners** include Digital Public Library of America, HathiTrust, Milwaukee Public Library, Milwaukee Public Museum, UWM Libraries, and the Wisconsin Library Services-Recollection Wisconsin program.

2.B Theoretical Frameworks. This project builds on **disability models and interactive information retrieval models**. Disability is an umbrella term that embraces various physical and cognitive impairments. Among the models that support multiple perspectives on disability, the most common are the medical, social, and gap models [55-57]. From a biomedical perspective, the **medical model** is grounded in "an undue emphasis on clinical diagnosis," focusing on "physical or intellectual characteristics" of individuals with impairments [58, p. 173]. For disabilities caused by disease or individual impairments, medical/therapeutic services and treatments are essential for coping with disability in the individual model [59]. In contrast, the **social model** is "the dominant paradigm in researching and understanding disability" [60, p. 145]. It maintains that disability is a product of social and institutional discrimination and exclusion [60-61], and action is required to create more inclusive and accessible environments [56]. The **gap model** concentrates on the solution, viewing disability as a mismatch between individuals' capabilities and demands from society and associated institutions [57, 62]. To bridge the gap, both individual and socio-structural dimensions of disability should be considered [63], implying that system improvement and user education/training efforts could play a vital role in helping BVI users in the IR context.

Interactive IR research forms its unique focus and specialty by incorporating research from IR, human information behavior, and human-computer interaction [64], Taking the leading roles, the episode model of interaction with texts, the stratified interaction model, and the integrated information seeking and retrieval framework concentrate on interaction with text, interaction at different levels, and interaction among the cognitive structure of diverse human actors, respectively [65-67]. Along with the primary interactive IR models, researchers have also created models emphasizing a specific aspect. For example, the berry-picking model emphasizes the dynamic nature of the IR process; the search situation and transition model and planned-situational interactive IR model illustrate how the social-organizational context, tasks, user, and system factors influence the interactive process; and the theory of the task-based IR process highlights the role of tasks in the IR process [68-71].

This proposed research applies the social and gap models of disability rather than the medical model. It will also contribute to creating new interactive IR models that incorporate both sighted and BVI users' search behaviors. First, the interactive IR models need to consider BVI users and focus on identifying the help-seeking situations in their interactions with DLs in mobile contexts. Second, existing research, including our own studies, shows that the impairment of the BVI users does not cause the situation but rather the sight-centered design that leads to the problems. The irony is that, although existing interactive IR models take a user-centered rather than a system-oriented approach, they still take a sight-centered approach without supporting people with disabilities, such as BVI users. Interactive IR models also need to preclude social discrimination and exclusion in system design and create accessible systems for all users.

2.C Research Questions. The project seeks to answer the following questions: 1) What are the limitations of existing design guidelines in addressing the help-seeking situations BVI users face in mobile contexts? 2) What unique help-seeking situations do BVI users encounter when interacting with DLs in mobile contexts? 3) What types of accessibility and usability guidelines are needed to help BVI users successfully interact with DLs in mobile contexts? 4) What are the perspectives of key DL stakeholders on mDLAUG? 5) What is the status of DL designs in compliance with mDLAUG? 6) What are the types of challenges that DL developers face when adopting and implementing the mDLAUG and associated solutions?

2.D Project Design. To address the research questions, the proposed project consists of four stages.
Stage 1: Build Foundation for mDLAUG (August 2022–January 2023, RQs 1, 2 & 3)
Identify unique help-seeking situations in mobile interactions by document analysis. Since very little research has studied the DL environment, we will review the literature published in the last 20 years to identify the help-seeking situations BVI users encounter in their mobile interactions. We will analyze both the physical and cognitive aspects of situations. The findings will enable the project team to draft design guidelines that address various help-seeking situations that BVI users may experience during their DL interactions using mobile devices. The open coding technique, which breaks down, examines, compares, conceptualizes, and categorizes unstructured textual transcripts [72], will be used. The document analysis will build on the literature review conducted in LIS and other related fields during the pilot study, as described in Project Justification. Four types of categories will be generated in the mobile environment: unique needs of BVI users, their help-seeking situations, factors leading to the situations, and their desired help needs. Findings will be verified and enhanced by data gathered from the user study in Stage 2.

Survey and analyze existing guidelines and papers. Two types of analyses will be conducted to identify the status of and problems with the existing guidelines related to accessibility and usability in mobile contexts: 1) evaluation of existing

accessibility and usability guidelines and 2) review of associated research on the guidelines. A comprehensive search will be conducted to identify the existing guidelines - both US and international - and associated papers over the last 20 years. The inclusion criteria are 1) guidelines, standards, or policies related to accessibility and usability for information systems, Web pages, software, etc., and 2) papers that address the coverage, components, structure, problems, or future directions of guidelines, standards, best practices, and policies. Next, the team will examine various aspects and components of the guidelines in detail, conduct a content analysis of the guidelines to provide an overview on the coverage, components, and structure of the existing guidelines, and identify the types of problems and future directions. Finally, BVI users' help-seeking situations and needs, as identified in the literature, will inform the user study and guidelines development in Stage 2. These two types of document analyses will complement each other, providing a comprehensive overview on how, where, and why existing guidelines fail to address the help-seeking situations and needs of BVI users of DLs in the mobile environment, with the goal of developing guidelines needed to fulfill these needs.

Stage 2: Develop draft mDLAUG (February 2023-April 2024, RQs 2 & 3)
Prepare IRB and recruit participants. Participants will be recruited from three different communities at various stages in developing mDLAUG. First, 120 BVI users will be recruited for a user study in diverse DL mobile contexts to identify help-seeking situations. Second, 150 stakeholders will be recruited for two-round Delphi surveys to provide feedback for the draft of mDLAUG. Third, 30 DL developers will be recruited to assess 12 DLs and participate in focus groups to identify the challenges in adopting and implementing mDLAUG and associated solutions. Since the BVI population comprises a low-incidence user population, recruiting a sufficient number of participants may be challenging. Participants will be recruited from BVI partner organizations (see Supportingdoc3.pdf) and NFB Net, Blind geek zone, Cool Blind Tech, as well as the National Organization of Blind Educators via emails, listservs, and social media. Additionally, the project consultants and advisory board will help with participant recruitment. **A total of 120 participants representing BVI users will be recruited,** with different characteristics across the US. Participants must a) be able to use a screen reader to access the Internet, b) have at least three years of experience in using mobile devices to search for information, and c) be 18 years or older. Potential participants will be prescreened via a pre-questionnaire. Each participant will receive $100 as an incentive for completing the study.

To reflect various opinions of heterogeneous stakeholders involved in the research, development, and use of DLs, a variety of stakeholders will participate in two-round Delphi surveys. First, **150 participants** (scholars/experts, DL developers, and BVI users) will be recruited. The number and the selection criteria of each group are:
- **Scholars/experts (N=50)**: *Scholars* **(N=25)**: scholars who have conducted research on accessibility and usability and have high citations. *Experts* **(N=25)** are professionals who perform accessibility and usability tests for BVI users. Experts will be recruited through organizations and units such as the American Foundation for the Blind Talent Lab, Microsoft Accessibility Business Unit, Google Accessibility team, and the Trace Research and Development Center. They will also be recruited at conventions, including the CSUN Assistive Technology Conference and the International Conference on Computers Helping People with Special Needs.
- **Digital library Developers (N=50)** are professionals responsible for DL creation (e.g., interface, content, metadata) for several years. Participants will be recruited through DL partners and advisory board members. Additionally, recruiting messages will be sent to related listservs (e.g., Diglib, Imagelib, Code4Lib, and Web4Lib).
- **BVI users (N=50)** are BVI users who satisfy the requirements of the user study specified above.

Each participant will complete the surveys that consist of three parts: demographics information; experience in researching, developing, or using DLs; and assessment of the mDLAUG draft and their needs. Each participant will receive $100 as an incentive for completing the study.

In addition, **30 of the 50 DL developers** who participated in the Delphi surveys will be recruited to participate in the DL assessment and focus groups. This participant group is necessary because 1) they will implement mDLAUG for designing and improving DLs, and 2) they are familiar with mDLAUG and will provide feedback for the draft mDLAUG. After completing the assessment, this group will participate in focus groups to discuss their experiences in applying mDLAUG to DLs. They will each be compensated $200 for their participation.

An Institutional Review Board (IRB) submission, which includes the recruitment flyer, consent form, and all instruments, will be submitted to the **UWM IRB for approval**.

Identify help-seeking situations via a user study. In Stage 2, the team will develop an understanding of various help-seeking situations that BVI users encounter in interacting with DLs while using various mobile devices and performing diverse search tasks, as well as the types of help needed to resolve these situations in mobile contexts. In addition, the team will investigate the factors that lead to such help-seeking situations. The results will enable the project team to

determine the specific needs of BVI users to develop mDLAUG. **Selected DLs** must include various content and media formats in which BVI users might be interested. We will select a diverse set of DLs for the study, such as stand-alone DLs with multiple digital collections with both app and web platforms, federated DLs, visual DLs, and DLs offering STEM content. Two types of search tasks (one assigned and one self-generated) will be employed to identify diverse types of interactions, including a specific-information search and a subject-oriented search. In a specific-information search, a user looks for exact data or facts; in a subject-oriented search, a user looks for items with common characteristics related to a specific topic [37]. Each participant will conduct each search task in two assigned DLs, and a total 12 representative DLs, including M. Web and M. App of DLs, will be selected for the user study.

120 BVI subjects will be divided into four groups (iOS phone, Android phone, iOS tablet, and Android tablet), with 30 subjects in each group. Multiple data collection methods will be applied to explore BVI users' help-seeking situations, including pre-search interviews, think-aloud protocols, transaction logs, and post-search interviews. Pre-search interviews will solicit demographic information. Mobile usability testing software, which captures participant verbalization, screenshots, and transaction logs, will also be used. Think-aloud protocols will provide detailed information about BVI users' perception of their help-seeking situations and desired features. Transaction logs will show the unique help-seeking patterns of BVI users. Post-search interviews will ask participants to identify typical problems in fulfilling the search tasks, factors leading to the issues, interface features used, and desired features. Our pilot study demonstrated that these data collection methods work for BVI participants. The team will modify the pilot study instruments (See Supportingdoc1.pdf) for the proposed project.

Data will be analyzed both qualitatively and quantitatively. Based on open coding, the project team will identify the types of help-seeking situations that BVI users encounter during the search process and associated factors, as well as desired help needs. First, qualitative data will be analyzed using open coding, as specified in Stage 1. Taxonomies of help-seeking situations will be identified and categorized into help-seeking situations unique to BVI users at the physical and cognitive levels. Second, open coding will be applied to discover types of factors and associated help needs for each type of help-seeking situation. Third, the comparison of the frequency of help-seeking situations in the four groups will be analyzed by applying ANOVA or the Kruskal-Wallis test, depending on the data distribution. Fourth, relationships between factors (e.g., user, system design, task, interaction outcomes) and different types of help-seeking situations in diverse groups will be analyzed by applying multivariate analysis and/or multiple regressions.

Develop draft mDLAUG. Based on Stage 1, draft mDLAUG will be developed using the dDLAUG structure created by the project team and WCAG structure. The document analysis includes a review of WCAG and other guidelines that will be reviewed alongside BVI users' help-seeking situations and challenges in the mobile environment.

To draft the mDLAUG, the project team will analyze and re-analyze the user study results using open coding and compare findings to the existing guidelines. Essential DL design guidelines will be identified in relation to accessibility and usability. Based on document analysis and user study analysis, design guidelines will be organized according to the types of **Help-seeking Situations** associated with accessibility and usability. The **Definition** of each type of help-seeking situation will be specified; **Factors** that lead to the situation will be identified; **Guidelines or Design Recommendations** to solve the situation will be developed; **Rationale and Objectives** providing a set of reasons behind the creation of guidelines will be offered; **Techniques and Methods** to comply with a specific DL design guideline will be suggested; **Features** to implement a specific technique or method will be recommended; **Examples** that show good and/or bad designs for a recommended feature will be provided; **Related Resources** consisting of extra resources corresponding to the situation will be presented; and a **See Also** section linked to the corresponding situation category will be added. In addition, a **Glossary** will present definitions of key terms. **Appendices** will include: How to conduct a user study, Types of factors, Levels of conformance recommendations, Similarities and differences between the mDLAUG and WCAG2.1, Keyboard shortcuts, and Accessibility assessment tools. Three levels of **conformance recommendations** will determine how well the mDLAUG supports the help needs of BVI users: A = minimum compliance, AA = partial compliance, and AAA = full compliance based on user studies.

Stage 3: Refine mDLAUG (May 2024-November 2024, RQ 4)

To obtain feedback on mDLAUG, **two-round Delphi surveys** will be administered to 150 participants representing three groups of stakeholders. Data obtained in Stages 1 and 2 will inform the development of the Delphi surveys. The purpose of the **first round** is to solicit qualitative and quantitative feedback on the mDLAUG drafted in Stage 2 and their specific needs. The survey will instruct participants to review mDLAUG and suggest additional changes they perceive to be desirable, ensuring the design guidelines and their components are relevant to different groups of stakeholders. Quantitatively, the Delphi survey will instruct participants to use a "1 to 7" Likert scale. Five questions will

be asked for each component related to importance, relevance, clarity, feasibility, and usefulness. Importance will serve as a key variable to rank each component. Qualitatively, suggested modifications will be analyzed using open coding. In addition, the stakeholders will be asked to express their needs for adopting, implementing, and assessing mDLAUG. Quantitatively, ANOVA or the Kruskal-Wallis test, depending on the data distribution, will be applied to compare the assessment from the three groups. In the **second round**, participants will review the updated mDLAUG quantitatively and qualitatively in the same format as the first round. The findings of the second round will help the research team modify mDLAUG to support BVI users to use mobile DLs.

Stage 4: Test and finalize mDLAUG and disseminate project findings (December 2024-July 2025, RQs 5 & 6)
Apply mDLAUG for DL compliance assessment and finalize mDLAUG. At this stage, mDLAUG will be used to assess the same 12 DLs representing different types of DLs selected for the user study. Each of the 30 DL developers selected from Stage 3 will be instructed to assess two of the selected DLs based on mDLAUG. In total, each DL will be evaluated by five DL developers. The objectives of this task are twofold: 1) the guidelines will be tested to determine whether they can be used to assess DLs, and further enhancements will be suggested to improve the DL design guidelines, and 2) mDLAUG will be used to assess the current status and conformance levels of the 12 DLs to determine whether they meet conformance criteria for accessibility and usability for BVI users. Each DL will be assessed qualitatively (exemplary and poor designs) by open coding and quantitatively (the extent of DL's conformance by descriptive analysis) to review the status of the DLs. Each DL will be assessed based on the design guidelines specified by mDLAUG. Simultaneously, each DL developer will also record their problems in applying mDLAUG and make suggestions for improvement. Each component of mDLAUG will be rated numerically for its importance, relevance, clarity, feasibility, and usefulness for its application.

Following the DL assessment, four focus groups, seven to eight participants each, will discuss their experience in assessing the DLs using mDLAUG. Focus groups will provide suggestions on how to best finalize mDLAUG, and participants will discuss the challenges and solutions in the adoption and implementation of mDLAUG. Since participants reside throughout the U.S., focus groups will occur online asynchronously. Canvas, an online learning platform, particularly its Discussion component, will be used to facilitate and record the focus groups' discussions. Focus groups will seek modification suggestions to address the problems. Focus groups will be analyzed using open coding, as discussed in Stage 2. Taxonomies of problems with the guidelines and suggested modifications will be identified from the data. Based on the feedback from the 30 DL developers, the project team will finalize mDLAUG. Next, the types of challenges and associated solutions when adopting and implementing mDLAUG will be highlighted. Finally, the project team will compare mDLAUG to dDLAUG to highlight all the unique components in the mobile DL environment, such as situations, factors, design guidelines, techniques and methods, and features.

Disseminate project findings. **1) Partnerships.** We will work closely with advisory board members, partners, various associations, consortia, and organizations (e.g., DLF, ALA, DPLA, HathiTrust, IFLA, and W3C) to recommend mDLAUG for integration into the existing guidelines (e.g., WCAG, IFLA's DL Guidelines) and to nationally disseminate and promote mDLAUG via news releases, panel discussions, publications, workshops, etc. **2) mDLAUG Forum and Community.** We will create a website to present our findings and products, including mDLAUG and associated tutorials. Most important, we will incorporate **an interactive communication platform with social Q&A features** on the website that allows users to ask and answer questions, share ideas, evaluate content submitted by others, and view the community's collective knowledge on a given topic related to mDLAUG. This forum will be open to the BVI users, DL developers, accessibility and usability experts/scholars, in addition to the research team, advisory board members, and partners, as well as anyone interested in the topic. Moreover, this forum can serve as a foundation for us to **build a community** to support the design of accessible and usable DLs for BVI users. This forum will enable the project team to directly solicit feedback on the mDLAUG Forum from the advisory board and various stakeholder groups and encourage the community to share ideas on given topics, reaching consensus. We will create a specific topic regarding mDLAUG use and associated problems and solutions, enabling us to **track institutions that adopt and implement mDLAUG at different compliance levels.** The content-focused and collaborative nature of the social Q&A forums [73] will facilitate the rapid and widespread dissemination of the project's findings and the revision of mDLAUG. **3) Digital repository.** The UWM Digital Commons (http://dc.uwm.edu/), a virtual showcase for UWM's academic research and creative profiles, will be used as the repository to store the collected data, mDLAUG, and other associated documentation. In this way, the work will be hosted on a stable, visible online location that is searchable and citable. **4) Conferences.** We will present mDLAUG and offer workshops to librarians, developers, and vendors at **professional conferences** (e.g., ALA, CONTENTdm Users Group Meeting, DLF, Code4Lib) to help improve existing DL and

information system design. Project results will also be presented at **academic conferences** (e.g., JCDL, iConference, and ASIST) for application to research and **conferences on accessibility and usability** to promote mDLAUG for BVI users (e.g., CSUN Assistive Technology Conference, International ACM SIGACCESS Conference on Computers and Accessibility, International Technology & Persons with Disabilities Conference, International Conference on Computers Helping People with Special Needs). **5) Publications.** Findings will be submitted to respected scholarly and professional journals in the field (e.g., JASIST, IPM, and International Journal of Human-Computer Interaction). **6) Social media platforms.** Twitter and Facebook will be used to disseminate project updates, including major milestones and research findings, to the public and relevant stakeholders. We will create a team account on each social media site and encourage individual project team members, advisory board members, and partners to promote the project's progress and products on their accounts. Links to full documents, which will be hosted on the project website, will be included in each post. **7) Project reports.** Annual and final project reports will be submitted to IMLS. These communication channels were found to be very effective for disseminating project findings based on the previous IMLS project. While the project team received many emails regarding how our consultants, advisory board members, partners, and study participants have promoted and adopting dDLAUG, we do not have complete data about all the organizations that have adopted dDLAUG. Thus, we have decided to create an mDLAUG Forum to help us keep track of organizations that choose to adopt mDLAUG. They can also share their problems and solutions found in their mDLAUG implementation process.

3. DIVERSITY PLAN

This project focuses on a critical underserved group—BVI users. Given the unique and heterogeneous characteristics of BVI users, it is imperative to ensure their needs are accurately identified, represented, and portrayed. For the user study in Stage 2, we will strive for diversity in recruiting study participants from diverse demographic backgrounds, including age, gender, and race. Special attention will be paid to how older adult users (65 or older)—one of the most vulnerable user groups within the BVI population—interact with DLs in the mobile environment. Second, when recruiting participants in the user study, the causes of blindness and severe visual impairment will be considered and broadly grouped into congenital and acquired types. Third, participants with varying levels of information literacy and mobile device use and experience will be included to capture the different information-seeking strategies employed and barriers encountered by BVI users. Fourth, participants using screen readers that run on Android, iOS, or both will be solicited, as these two mobile platforms have an approximately 99% worldwide market share as of January 2022 [74]. As indicated in the project design, the team will work closely with partner organizations and the advisory board to recruit participants from diverse backgrounds.

At Stages 3 and 4, where the team will refine mDLAUG and understand stakeholders' needs, we will strive to obtain a diverse range of perspectives by incorporating the experiences, insights, and aspirations of three different stakeholder groups across the nation: 1) the BVI user group, 2) scholars and experts, and 3) digital library developers. The project team aims to solicit diverse feedback by considering the stakeholders' backgrounds in terms of age, gender, race, and other demographic factors, in addition to the types of organizations they are working for and the topics of research or digital collections they are dealing with.

4. PROJECT RESULTS, NATIONAL IMPACT, AND SUSTAINABILITY
4.A Results.

Products. The deliverable for this project will be a new framework for creating DLs for BVI users in the mobile environment. The new framework consists of 1) the **theoretical approach** that takes into account both social and gap disability theories and interactive IR models which consider all users rather than sighted users; 2) **the types of help-seeking situations** encompassing both design and content/format related difficulties that BVI users encounter in their interactions with DLs using various mobile devices; 3) **the limitations of the existing guidelines** for DLs in mobile contexts; 4) **mDLAUG** addressing each type of help-seeking situation; 5) **unique help-seeking situations and associated design guidelines** in the mobile environment compared with the desktop environment; 6) **a report** on how DLs currently comply with mDLAUG; 7) **challenges** that DL developers face in adopting and implementing mDLAUG and associated **solutions**; and 8) **methodology** that can be applied to develop similar guidelines for DLs and other types of IR systems to address additional groups of underserved users' mobile accessibility and usability issues.

Evaluation. The project team will utilize the four performance measures suggested by the National Leadership Grants for Libraries Program—effectiveness, efficiency, quality, and timeliness—to ensure the project goals are being met and the project is well-managed throughout the project period. Details of the measures employed, needed data types, sources and methods of data collection, and evaluation schedule are provided in the Performance Measurement Plan.

4.B National Impact.

Impact by filling the gap in mobile DL guidelines. DLs are increasingly becoming the preferred resource for searchers, supplementing physical interactions with traditional libraries. The proposed project will innovatively enhance the DL design for a key underserved group by creating mDLAUG to address BVI users' help-seeking situations in mobile contexts. As previously discussed, it is difficult for BVI users to interact with DLs via mobile devices. The limitations of existing design guidelines that do not holistically address these situations result in poor DL design and thus hinder BVI users' ability to use DLs effectively. Previous research has not developed guidelines for mobile DL design that support BVI users' accessibility and usability needs. The proposed research is the first of its kind and will impact DLs across the country by filling the gaps in existing guidelines.

Transformative impact on the DL field. The interdisciplinary nature of the project team and the involvement of different DL stakeholders—including accessibility and usability scholars and experts, DL developers, and BVI users— will impact the DL field by going beyond sight-centered design to support BVI users effectively interacting with mobile DLs. To ensure that mDLAUG and the other project products are widely disseminated to DL professionals, the project team will closely work with advisory board members and partners for the adoption and implementation of mDLAUG. For example, consultant Allan involved in W3C's Web Accessibility Initiative and board member Zeng of the IFLA's DL Guidelines Working Group will assist with the submission of mDLAUG to W3C and IFLA for their consideration, respectively. Similarly, board members Ferretti from DLF and Huddleston from OCLC will help with the dissemination of mDLAUG to all the members under DLF and OCLC. Partners DPLA and HathiTrust will use mDLAUG to improve their DLs and disseminate mDLAUG to their partners. Additionally, creating the mDLAUG Forum offers a platform for DL developers to share their challenges and solutions in adopting and implementing mDLAUG. This project will leverage this structure to register a transformative impact on the development of DLs to diverse beneficiaries.

Impact beyond BVI users. This research fulfills Goal 3 of the IMLS National Leadership Grants for Libraries, which aims to provide access to digital collections to all Americans and enhance digital infrastructure and platforms. The issues examined in this research are universal, as all users can potentially use DLs. While accessibility and usability problems in DLs are exacerbated for BVI users, they also create difficulties for other types of users, including the elderly and people with other types of disabilities (e.g., deaf users). Many elderly people also rely on screen readers to access information in the mobile environment, and 54.1 million elderly people (65 or older) in the U.S. could also directly benefit from the products of this project [75]. The methods employed in this project can be applied to generate DL design guidelines for other types of users, particularly the 61 million people with disabilities in the U.S. [76].

Impact beyond DLs and DL developers. The resulting mDLAUG can be implemented in different types of systems (e.g., DLs, web search engines, online databases, and online public access catalogs) because the guidelines offer detailed requirements for the system features needed to support BVI users in the mobile environment. The significance of this research is its universality, practical implications, and methodological approaches. The project activities and methodology will help researchers/experts design their own user and testing studies as well as develop their own design guidelines for any systems and/or platforms.

4.C Sustainability. Through consultants, advisory board members, and partners, mDLAUG will be submitted to W3C and IFLA for consideration and promoted to different DL organizations for adoption. mDLAUG will be broadly available to stakeholders involved in DL development, management, and use through multiple channels discussed above. Considering the obsolesce of the existing technology and the emergence of new technologies, the PIs will periodically review mDLAUG, conduct related studies, and/or incorporate feedback from the mDLAUG Forum, and update mDLAUG accordingly. Additionally, we will provide consultation to those who want to implement and adopt mDLAUG through the open mDLAUG Forum created for this project. The project team will sustain this project by applying for grants from IMLS, the National Science Foundation (e.g., Research in Disabilities Education), and the U.S. Department of Education (e.g., National Institute on Disability & Rehabilitation Research) to develop design guidelines for OPAC systems or other information systems in libraries or museums, as well as to extend the methodologies used in this project to support other types of underrepresented groups, including people with different types of disabilities, older adults, and children. The associated data will be updated on the UWM Digital Commons (http://dc.uwm.edu/) and all the project communication channels. Moreover, this project can serve as an exemplary study to develop mobile design guidelines for different user groups in diverse library/museum digital platforms.

5. REFERENCES (See Supportingdoc4)

Schedule of Completion

Schedule of Completion	2022-2023												2023-2024												2024-2025											
	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7
Stage 1. Build a foundation for DL design guidelines (6 months)	▓	▓	▓	▓	▓	▓																														
Identify unique help-seeking situations by document analysis	■	■	■																																	
Survey existing guidelines and papers by document analysis				■	■	■																														
Stage 2. Develop a Draft of mDLAUG (15 months)							▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓	▓															
IRB preparation and approval							■																													
Recruit BVI participants for user study								■	■																											
Recruit stakeholders for Delphi surveys								■	■																											
Recruit DL developers for DL assessment & focus groups								■	■																											
User study									▨	▨	▨	▨	▨	▨	▨	▨																				
Data collection									■	■	■	■	■	■																						
Data analysis															■	■																				
Develop draft mDLAUG																	■	■	■	■	■															
Stage 3. Refine mDLAUG (7 months)																						▓	▓	▓	▓	▓	▓	▓								
Administer Round One Delphi survey																						■	■													
Administer Round Two Delphi survey																								■												
Data analysis																									■	■										
Refine mDLAUG																											■	■								
Stage 4. Test and Finalize mDLAUG and disseminate project findings (8 months)																													▓	▓	▓	▓	▓	▓	▓	▓
Apply mDLAUG for DL Assessment and finalize mDLAUG																													▨	▨	▨	▨	▨			
Assess DL conformance levels																													■	■						
Focus group discussions																														■	■					
Data analysis																															■	■				
Finalize mDLAUG																																■	■			
Disseminate project findings																																			▨	▨
Report writing																																			■	■
Dissemination & Implementation																																			■	■

Digital Products Plan

• Type: What types of digital products will you create?

The deliverable for this project will be a new framework for creating DLs for BVI users in the mobile environment. The new framework consists of 1) the theoretical approach that takes into account both social and gap disability theories and interactive IR models which consider all users rather than sighted users; 2) the types of help-seeking situations encompassing both design and content/format related difficulties that BVI users encounter in their interactions with DLs using various mobile devices; 3) the limitations of the existing guidelines for DLs in mobile contexts; 4) mDLAUG addressing each type of help-seeking situation; 5) unique help-seeking situations and associated design guidelines in the mobile environment compared with the desktop environment; 6) a report on how DLs currently comply with mDLAUG; 7) challenges that DL developers face in adopting and implementing mDLAUG and associated solutions; and 8) methodology that can be applied to develop similar guidelines for DLs and other types of IR systems to address additional groups of underserved users' mobile accessibility and usability issues.

• Availability: How will you make your digital products openly available (as appropriate)?

We will make our digital products openly available via the following channels:
1) Partnerships. We will work closely with advisory board members, partners, various associations, consortia, and organizations (e.g., DLF, ALA, DPLA, HathiTrust, IFLA, and WAI) to recommend mDLAUG for integration into the existing guidelines (e.g., WCAG) and to nationally disseminate and promote mDLAUG via news releases, panel discussions, publications, workshops, etc. 2) mDLAUG forum and community. We will create a website to present our findings and products, including mDLAUG and associated tutorials. Most important, we will incorporate an interactive communication platform with social Q&A features on the website that allows users to ask and answer questions, share ideas, evaluate content submitted by others, and view the community's collective knowledge on a given topic related to mDLAUG. This forum will be open to the BVI users, DL developers, accessibility and usability experts/scholars, in addition to the research team, advisory board members, and partners, as well as anyone interested in the topic. Moreover, this forum can serve as a foundation for us to build a community to support the design of accessible and usable DLs for BVI users. This forum will enable the project team to directly solicit feedback on the mDLAUG forum from the advisory board and various stakeholder groups and encourage the community to share ideas on given topics, reaching consensus. We will create a specific topic regarding mDLAUG use and associated problems and solutions, enabling us to track institutions that adopt and implement mDLAUG at different compliance levels. The content-focused and collaborative nature of the social Q&A forums [73] will facilitate the rapid and widespread dissemination of the project's findings and the revision of mDLAUG. 3) Digital repository. The UWM Digital Commons, a virtual showcase for UWM's academic research and creative profiles, will be used as the repository to store the collected data, mDLAUG, and other associated documentation. In this way, the work will be hosted on a stable, visible online location that is searchable and citable. 4) Conferences. We will present mDLAUG and offer workshops to librarians, developers, and vendors at professional conferences (e.g., ALA, DLF, Code4Lib, and Educause) to help improve existing DL and information system design. Project results will also be presented at academic conferences (e.g., JCDL and ASIST) for application to research and conferences on accessibility and usability to promote mDLAUG for BVI users (e.g., CSUN, International Technology & Persons with Disabilities Conference, Accessing Higher Ground Accessible Media Web and Technology Conference, and International Conference on Computers Helping People with Special Needs). 5) Publications. Findings will be submitted to respected scholarly and professional journals in the field (e.g., D-Lib, JASIST, IPM, and Journal of Human-Computer Interaction). 6) Social media platforms. Twitter and Facebook will be used to disseminate project updates, including major milestones and research findings, to the public and relevant stakeholders. We will create

a team account on each social media site and encourage individual project team members, advisory board members, and partners to promote the project's progress and products on their accounts. Links to full documents, which will be hosted on the project website, will be included in each post. 7) Project reports. Annual and final project reports will be submitted to IMLS. These communication channels were found to be very effective for disseminating project findings based on the previous IMLS project. While the project team received many emails regarding how our consultants, advisory board members, partners, and study participants have promoted and considered adopting dDLAUG, we do not have complete data about all the organizations that have adopted dDLAUG. Thus, we have decided to create an mDLAUG forum to help us keep track of organizations that choose to adopt mDLAUG. They can also share their problems and solutions in their mDLAUG implementation process.

• Access: What rights will you assert over your digital products, and what limitations, if any, will you place on their use? Will your products implicate privacy concerns or cultural sensitivities, and if so, how will you address them?

Digital products of this project are under open access license that public can access and reuse. There is no known risk in products for privacy concerns or cultural sensitivities because the research team will protect the subjects by only revealing each participant's identification number, and only trained research team members will have access to the collected data. Also, the research design of the project will be thoroughly examined by the IRB of UW-Milwaukee. We will not start any data collection activity before receiving approval from the IRB. The link between the collected data and the identification information of the individuals will be destroyed after the data coding is completed. Before that, the link data will be securely protected by using password in the UWM network. In addition, audio/video data will be transcribed into text. The public can only access the data associated with the subject ID and transcription data.

• Sustainability: How will you ensure the sustainability of your digital products?

Through consultants, advisory board members, and partners, mDLAUG will be submitted to W3C and IFLA for consideration and promoted to different DL organizations for adoption. mDLAUG will be broadly available to stakeholders involved in DL development, management, and use through multiple channels discussed above. Considering the obsolesce of the existing technology and the emergence of new technologies, the PIs will periodically review mDLAUG, conduct related studies, and/or incorporate feedback from the mDLAUG forum, and update mDLAUG accordingly. Additionally, we will provide consultation to those who want to implement and adopt mDLAUG through the open mDLAUG forum created for this project. The project team will sustain this project by applying for grants from IMLS, the National Science Foundation (e.g., Research in Disabilities Education), and the U.S. Department of Education (e.g., National Institute of Disability & Rehabilitation Research) to develop design guidelines for OPAC systems or other information systems in libraries or museums, as well as to extend the methodologies used in this project to support other types of underrepresented groups, including people with different types of disabilities, older adults, and children. The associated data will be updated on the UWM Digital Commons (http://dc.uwm.edu/) and all the project communication channels. Moreover, by offering detailed information about each project stage, this project can serve as an exemplary study to develop mobile design guidelines for different user groups in diverse library/museum digital platforms.

Data Management Plan

Identify the type(s) and estimated amount of data you plan to collect or generate, and the purpose or intended use(s) to which you expect them to be put.
At stage 1 (August 1, 2022 – January 31, 2023), two document analyses will be performed to address: 1) help-seeking situations and needs of BVI users in DLs; and 2) existing design guidelines on accessibility and usability in digital environments and their problems. At stage 2 (February 1, 2023 – April 30, 2024), a user study will identify 120 BVI users' help-seeking situations in DLs when performing specific search tasks and the types of help needed to resolve these situations. Multiple data collection methods, such as pre-search interviews, think-aloud protocols, transaction logs, and post-search interviews, will be used to collect data. At Stage 3 (May 1, 2024 – November 30, 2024), two-round Delphi surveys will be administered to four groups of stakeholders (150 total) to provide quantitative and qualitative feedback for the draft of guidelines. mDLAUG will be refined. At Stage 4 (December 1, 2024 – July 31, 2025), 30 DL developers will use the guidelines to assess 12 DLs and test the feasibility of mDLAUG. After that, focus groups will be formed to discuss participants' experience with the assessment including identifying the challenges and associated solutions in implementing and adopting mDLAUG.

Will you collect any sensitive information? Detail the specific steps you will take to protect the information while you prepare it.
Demographic data and video records will be collected. However, there is no known risk to research subjects in participating in the research. The research team will use identification (ID) numbers, which will be randomly assigned, to protect personal information. Only trained research team members will have access to the collected data. Also, the research design of the project will be thoroughly examined by the IRB of UW-Milwaukee. We will not start any data collection activity before receiving approval from the IRB. The link between the collected data and the identification information of the individuals will be destroyed after the data coding is completed. Before that, the link data will be securely protected by using password on the UWM network. In addition, audio/video data will be transcribed into text. The public can only access the data associated with the subject ID and transcription data.

What technical (hardware and/or software) requirements or dependencies would be necessary for understanding retrieving, displaying, processing, or otherwise reusing the data? How can these tools be accessed?
The collected data will be in the formats of video, audio, and transaction logs that record subjects' activities while completing given search tasks. We will use identification (ID) numbers, which will be randomly assigned, to protect personal information. Collected data will be aggregated in the process of data analysis. All data, including consent forms, associated demographic data and video records, collected from participants will be stored on the UWM network under the project account, and the link data will be securely protected by using password. Only authorized research team members can access the data under the permission of the PIs. UWM Digital Commons (http://dc.uwm.edu/) will serve as the permanent repository to store the collected data for public access. This data will only be associated with the subject ID and audio/video transcription, as well as project products that can be accessed by the public. No specific technical requirements are needed for retrieving or using the data.

What documentation will you capture or create along with the data? Where will the documentation be stored and in what format(s)? How will you permanently associate and manage the documentation with the data it describes to enable future reuse?
The collected data will be used to generate the new framework consisting of: The deliverable for this project will be a new framework for creating DLs for BVI users in the mobile environment. The new framework consists of 1) the theoretical approach that takes into account both social and gap disability theories and interactive IR models which consider all users rather than sighted users; 2) the types of help-seeking situations encompassing both design and content/format related difficulties that BVI users

encounter in their interactions with DLs using various mobile devices; 3) the limitations of the existing guidelines for DLs in mobile contexts; 4) mDLAUG addressing each type of help-seeking situation; 5) unique help-seeking situations and associated design guidelines in the mobile environment compared with the desktop environment; 6) a report on how DLs currently comply with mDLAUG; 7) challenges that DL developers face in adopting and implementing mDLAUG and associated solutions; and 8) methodology that can be applied to develop similar guidelines for DLs and other types of IR systems to address additional groups of underserved users' mobile accessibility and usability issues. The documents will be saved in PDF format. The collected data and products will be stored in UWM Digital Commons (http://dc.uwm.edu/) which serves as the permanent repository to store the collected data. This data will only be associated with the subject ID and audio/video transcription of audio/video data that can be accessed and reused by the public. Any associations between the project documentation and collected data will be indicated in the notes.

What is your plan for managing, disseminating, and preserving data after the completion of the award-funded project? If relevant, identify the repository where you will deposit your data. When and for how long will data be made available to other users?
A project website will be created to present our findings and products, including mDLAUG and associated tutorials. As part of the website, we will create an mDLAUG forum implementing social Q&A features, which will allow users to ask and answer questions, evaluate content submitted by others, and view the community's collective knowledge on a given topic. Reports of the project will be submitted to IMLS and deposited in online databases. Most important, the team will work with our advisory board members and partners to recommend mDLAUG for integration into the existing guidelines (e.g., WCAG). These project products will be kept and regularly updated after the grant period by the team. The UWM Digital Commons (http://dc.uwm.edu/) will be used as the repository to store the collected data, mDLAUG, and other associated documentation. Multiple channels will be used to disseminate the findings of this project besides the project website. The team will work closely with advisory board members, partners, various associations, consortiums, and organizations (e.g., DLF, ALA, DPLA, HathiTrust, IFLA, and WAI) to disseminate and promote guidelines (e.g., news release, panel discussions, publications, workshops) nationally. Also, the researchers will present the findings and offer workshops to librarians, developers, and vendors at professional conferences (e.g., ALA, DLF, Code4Lib, and Educause) so that the guidelines can lead to the improvement of existing DL and information system design. Results will be presented at academic conferences (e.g., JCDL and ASIST) so that researchers in the field may apply the findings to their research. Findings will be submitted to respected scholarly and professional journals in the field (e.g., D-Lib, JASIST, and Journal of Human-Computer Interaction). Presentations and workshops will be offered at different conferences on accessibility and usability to promote mDLAUG for BVI users (e.g., CSUN, International Technology & Persons with Disabilities Conference). In addition, Social media, such as Twitter and Facebook, will be used to disseminate updates on the project, including major milestones and research findings, to the public. We will create a team account on each social media site and encourage individual project team members, advisory board members, and partners to use their accounts to promote the project's progress and products. We will make the data available as long as they are relevant to the field.

When and how frequently will you review your Data Management Plan? How will the implementation be monitored?
The data management plan will be submitted to the University of Wisconsin-Milwaukee IRB Board for review of prepared documents and plans for data sharing and re-use after the completion of the project. The research team will check the status of data management for the collected data every six months. Also, the team will consult with the UWM Libraries' data service librarians to assess the data management plan throughout the project. The data management plan will be evaluated at every stage of the project, and the final report to IMLS will include how the team manages and stores the research data during and after the project.

The University of Wisconsin-Milwaukee Organizational Profile

The University of Wisconsin-Milwaukee (UWM) is one of two public doctoral research universities in the state with $44.7 million in annual research expenditures, offering approximately 24,000 enrolled students a comprehensive liberal arts and professional education through 206 degree programs. The main campus occupies 104 acres on the upper eastside of Milwaukee. Located in the economic and cultural capital of Wisconsin, UWM opens doors to 21st-century career connections and world-class learning opportunities for the most diverse population of students in Wisconsin.

UWM Select Mission Statement
To fulfill its mission as a major urban doctoral university and to meet the diverse needs of Wisconsin's largest metropolitan area, the University of Wisconsin-Milwaukee must provide a wide array of degree programs, a balanced program of applied and basic research, and a faculty who are active in public service. Fulfilling this mission requires the pursuit of these mutually reinforcing academic goals:

- To develop and maintain high-quality undergraduate, graduate, and continuing education programs appropriate to a major urban doctoral university.

- To engage in a sustained research effort which will enhance and fulfill the University's role as a doctoral institution of academic and professional excellence.

- To continue development of a balanced array of high-quality doctoral programs in basic disciplines and professional areas.

- To attract highly qualified students who demonstrate the potential for intellectual development, innovation, and leadership for their communities.

- To further academic and professional opportunities at all levels for women, minority, part-time, and financially or educationally disadvantaged students.

- To establish and maintain productive relationships with appropriate public and private organizations at the local, regional, state, national, and international levels.

- To promote public service and research efforts directed toward meeting the social, economic, and cultural needs of the state of Wisconsin and its metropolitan areas.

- To encourage others from institutions in the University of Wisconsin System and from other educational institutions and agencies to seek benefit from the University's research and educational resources such as libraries, special collections, archives, museums, research facilities, and academic programs.

- To provide educational leadership in meeting future social, cultural, and technological challenges.

School of Information Studies (SOIS)
SOIS educates post-secondary students at all levels, offering a B.S. program in Information Science and Technology, an American Library Association accredited Master of Library and Information Science Program, and a Ph.D. program in Information Studies. The faculty members of SOIS have been ranked among the top four most productive schools of library and information science in terms of numbers of refereed journals articles per faculty member.

SOIS Mission Statement
SOIS a leading and collaborative school, advancing knowledge and preparing students from diverse backgrounds to be successful information professionals within their communities.