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**Steps Toward Integrating Accessibility into Development
of an Internet Option for the 2010 U.S. Census**

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Abstract

The potential benefits of electronic data collection include timely receipt of data and improvements in data quality. Such benefits cannot be achieved, however, unless significant numbers of potential respondents opt to submit their data electronically. Making electronic forms usable by and appealing to all potential respondents presents a challenge to software designers and developers. Since 2000, the U. S. Census Bureau has been prototyping and testing various iterations of a Census Internet form while paying attention to usability and accessibility issues. During this time, the Census Bureau's software development process has also been maturing to include traditional software lifecycle processes that have the potential for integrating usability and accessibility. Designing for usability and accessibility is becoming part of the agency's culture. The objective of a fully integrated process is to provide not only a functional Internet form, but also one that is accessible and usable by all respondents who have the capability to submit their data electronically.

1 Introduction

The U. S. Census Bureau has conducted a national census of population and housing every ten years since 1790. This operation is known as the "decennial census." For over 200 years, the Census Bureau has used paper forms to collect data from decennial respondents. In modern times, data from the short and long versions of the paper forms have been keyed into the census database. Electronic data collection has the potential for improving the timeliness and accuracy of the data (Brady, Stapleton, & Bouffard, 2004), but the electronic forms need to be both accessible to and usable by all respondents who have the capability to submit their data electronically. The objective of a design-and-development process into which both usability and accessibility are fully integrated is to provide a functional, usable, and accessible Internet form for the collection of census data in 2010.

In Census 2000, an electronic alternative to the census short form was available for the first time. This alternative was an Internet application closely imitating the visual design of the paper form and developed in house. Attention was given to accessibility for respondents with disabilities in Census 2000 in anticipation of the passage of the amendments to the Rehabilitation Act of 1983 (Section 508), which did not actually occur until June 2001. Since then, passage of the Section 508 standards (U. S. Access Board, 2000) has focused attention on legal requirements for making electronic forms accessible to such respondents. Under Section 508 of the Rehabilitation Act (29 U.S.C. §794d), employees of government agencies and members of the public who have disabilities are entitled to *comparable* access to electronic information, *comparable*, that is, to the access available to users without disabilities (U. S. General Services Administration, 2002). For example, users with disabilities must be provided with the means to interact with the input and control functions of any electronic system. This means, for example, providing keyboard alternatives for those who have difficulties using a mouse.

Since 2000, the design of a more usable and accessible Census Internet form has been evolving in a more structured software-development environment. The software development process has included formal requirements definition and documentation; iterative development and user-interface-design reviews; at least one round of usability and accessibility testing, and a formal change-control procedure. Usability appears to be more fully integrated into the design and development process, as compared to accessibility (cf. the experience at the Social Security Administration as described by Hoffman & Battle, 2005). It has taken over five years of project experience with usability for early involvement of usability to gain acceptance.

Although expert guidance is provided with regard to Section-508 issues during user-interface-design reviews, it is not possible to conduct testing with special-needs users until the later stages of development if the coding required for accessibility is added only during the final phases of implementation. This is an accepted practice, but it stands in contrast to the early integration advocated by state-of-the art software engineering processes that insert accessibility engineering into the development process so that early and iterative feedback can be obtained from users with special needs (e.g., Addleston & O'Connell, 2005; Hix and O'Connell, 2005). Project time constraints need to be managed creatively to allow for the early integration of both usability and accessibility testing with live participants.

2 Accessibility of the Census 2000 Internet Form

Software development for the Census 2000 Internet form was an in-house effort that focused on providing functionality and supporting the electronic receipt of data from up to 8,000,000 expected respondents. The development team followed a Rapid Application Development (RAD) approach (e.g., Maner, 1997). As is typical in RAD-based development efforts, there was a master plan for the program, but no documented requirements. An effort was made to evaluate usability: Two rounds of usability testing were conducted, and some recommendations on the user-interface design were implemented (Murphy, Marquis, Nichols, Kennedy, & Mingay, 2001). Change control consisted of an informal, undocumented process by which the developer assessed the impacts of proposed changes and implemented the changes that he deemed cost effective.

Accessibility for users with disabilities was a goal from the beginning, and the passage of the Section 508 amendments was anticipated prior to the launch of the Census 2000 Internet form. The intention was to incorporate accessibility by implementing the checkpoints of the Web Content Accessibility Guidelines (WCAG) and by closely adhering to the Hypertext Markup Language (HTML) 4.0 Transitional standard, as recommended by WCAG (Chisholm, Vanderheiden, & Jacobs, 2001). All images included ALT tags. The development team avoided nested/embedded HTML tables to the extent possible, and they tried to put checkbox labels in the same table cell as the checkbox. The development team did not realize until later that the available screen-reader technology could not take advantage of the features of HTML 4.0 Transitional (D. Coon, personal communication, January 11, 2005).

At that time, the Census Bureau's Usability Laboratory did not have capabilities for evaluating compliance with the proposed Section 508 amendments, which were not actually enacted until June 2001. To assess accessibility, a member of the development team visited the National Federation for the Blind (NFB) in Baltimore, with the Census 2000 Internet form on floppy disks. The NFB had legacy versions and the newest versions of all the major screen readers, which were used to test the form's accessibility. Even though the code had been written to the latest standard of HTML Transitional 4.0, the screen readers at NFB could not easily interpret the Census Internet form.

Use of the Census 2000 Internet form to submit household data required successful navigation of an up-front authorization process for the user to gain access to the form itself. A major step in this process was the user's entry of a 22-digit housing unit identification number, referred to as the Census Identification Number. Users with visual impairments needed to have a Kurzweil reader¹ or the help of a sighted person to find their Census Identification Number, which was printed on the back of the paper form, underneath a bar code.

In the 18 months spent developing an online option for Census 2000, the emphasis was on implementing functionality and storage capacity. With regard to the user interface, the developer's mandate was to mimic the paper form in order to minimize potential mode effects (i.e., differences in data quality between data collected via paper forms versus data collected via the Internet form). Therefore, the Census 2000 Internet form was a scrollable form with the same number of spaces for household members as provided on the paper form. The visual design was as close to that of the paper form as possible in the electronic medium. There were no automated pre-fills or dynamic edits. JavaScript was avoided because its use was believed to reduce accessibility.

For reasons related to actual and perceived security of personal data, the existence of the Census 2000 Internet form was not widely advertised to the public. Because the mailing packages had been prepared and printed before the final decision was made to launch an Internet form, the URL was not provided in the Census 2000 mailing package.

¹ For information, see http://www.kurzweiledu.com/products_k1000.asp

Therefore, the approximately 76,000 electronic respondents somehow discovered the Census 2000 Internet form, perhaps through creative browsing or with the help of a few articles that appeared in the mainstream and technical press, magazines, trade journals, and newspapers. It is unlikely that very many of these respondents were visually impaired or otherwise disabled.

Lessons learned from the experience with the Census 2000 Internet form included the need for documented requirements, including requirements for usability and accessibility, and the need for a formal change-control process.

3 Towards an Accessible Internet Form for Census 2010

In the years since Census 2000, two experimental versions of a Census Internet form have been designed, developed, and launched. A third version is under development for the 2005 National Census Test. In each case, compliance with the Section 508 regulations has been a specified requirement, and formal change-control processes have been in place. In development of an Internet option for the 2003 National Census Test, accessibility testing included working with several visually impaired users. The Census Bureau's Usability Lab acquired an adjunct Accessibility Lab; and trained staff evaluated the accessibility of the Internet form for the 2004 Overseas Enumeration Test using a Section-508 validator (Insight/InFocus) and a screen reader (JAWS®). The InSight™ software automates the diagnosis of Section-508 violations; and the InFocus™ software supports correction of the identified violations (SSB Technologies, 2004).

The testing planned for the two versions of the 2005 Census Internet form includes both the use of automated, Section-508 evaluation tools and the involvement of test participants with visual disabilities.² Prototyping and testing will continue into 2008, when “dress rehearsals” will be held to identify any remaining design issues prior to making designs final for both paper and Internet forms. Thus, the ultimate design of an Internet form for Census 2010 will have been through numerous iterations of automated and manual testing for usability and accessibility.

3.1 Requirements Specification

Since 2000, the specification of requirements for a Census Internet form has become a rigorous process. In validating and implementing requirements for the 2003 National Census test, the 2004 Overseas Enumeration Test, and the 2005 National Census Test, the contractor (Z-Tech Corp.) has followed the Rational Unified Process (RUP) framework for software production (e.g., Booch, Martin, & Newkirk, 1998). RUP-based requirements specifications include both functional and “non-functional” requirements. The so-called non-functional requirements are also referred to as user requirements, that is, requirements for user interaction with the software, typically depicted in use cases.³

In the area of accessibility, requirements have included compliance with Section 508 and with the Census Bureau's in-house IT Standard on Web design, which incorporates all 16 paragraphs of Section 508. The contractor is also responsible for adhering to the U. S. Department of Commerce⁴ standards, which incorporate Section 508.

With the introduction of the Capabilities Maturity Model (CMM) at the Census Bureau, formal documentation of requirements has become standard operating procedure. Following a rigorous process, high-level requirements are decomposed and requirements at all levels are thoroughly documented. This process has the strong support of Census Bureau management at all levels.

3.2 Formal Change Control

² Future testing will include test participants with cognitive and motor disabilities.

³ A limitation of use cases is that they do not depict unusual or unexpected use of the software.

⁴ The Census Bureau is an agency within the U. S. Department of Commerce.

Since 2000, the Census Bureau has also instituted a formal change control process within all major software-development projects. Once a requirement has been baselined, a change-control request must be submitted to a change-control review board. The contractor evaluates the change-control request for cost impacts (i.e., time and budget). Changes based on usability and accessibility testing are subject to the same change-control process as are changes based on other, more standard kinds of software testing (e.g., performance testing, user acceptance testing), which focus on verifying that functional requirements have been met. Requested changes and their disposition are thoroughly documented.

3.3 Iterative Testing

Usability testing has been built into the development schedule for each of the Census Internet forms. Automated accessibility testing has typically been conducted in parallel with usability testing; but testing with blind or otherwise visually impaired participants has occurred only in the final phase. Based on discussion and team decision-making, requests for software changes have been submitted to the change-control process.

3.3.1 One Iteration

In preparation for the 2003 National Census Test, one round of usability testing was built into the schedule. Similarly, one round of accessibility testing was conducted. Although several changes were made based on test results, it was not possible to confirm or disconfirm the effectiveness of the changes prior to launching the site. A lesson learned was that at least two rounds of usability and accessibility testing should be planned so that software changes made after the first rounds can be re-tested. As recommended in the usability literature, re-testing is necessary to verify that the changes have been effective and that no new problems have been introduced (e.g., Dumas & Redish, 1999).

A positive, meta-outcome of the usability testing for the 2003 National Census Test was the support for usability testing that developed within project management and the design team. The team recognized that it would have been better for the product if we could have conducted another round of usability testing. A commitment was made to build two rounds of usability testing into the next phase of the overall project, i.e., the 2004 Overseas Enumeration Test.

3.3.2 Two Iterations

Two rounds of usability and accessibility testing were planned and conducted during the development of the Internet form for the 2004 Overseas Enumeration Test. The first round of accessibility testing with a screen reader identified the following kinds of accessibility violations:

- Abbreviations that could confuse users of screen readers
- Inaccessible files in Portable Document Format (PDF) listing questions and answers about the 2004 Overseas Enumeration Test⁵
- Illogical tabbing order
- Unlabeled fields for data entry

The screen reader used for this testing was Job Access with Speech or JAWS®, version 5 (Freedom Scientific, 2004). To detect instances on non-compliance with Section 508, an accessibility specialist listened to JAWS read the online form.

Once documented, violations of usability principles and accessibility regulations were discussed by the design team, and a team decision was made and documented. For example, the team decided to require the contractor to spell out certain abbreviations: “Apt. No./Location” was to be displayed as “Apartment Number/Location.” The inaccessible PDFs remained problematic for Acrobat 6 to read through JAWS. Since the Census Bureau did not have the resources to make the PDFs accessible, the final resolution was to place a statement on the Web page with contact information for anyone who had visual problems with the PDFs. A software solution was found and implemented to

⁵ Later versions of the PDF software have resolved accessibility issues.

correct the tabbing order. Changes made following the first round of testing resolved about 44% of the identified accessibility issues, at least to some degree. Resolution of the remaining issues was deferred until later rounds of prototyping.

In the second round of accessibility testing, we identified issues through testing the user interface with two participants who had visual disabilities, as well as through the use of software tools (InFocus 4.2.1 and JAWS 5). One participant was legally blind and used the screen reader exclusively. He did not even glance at the screen. The second participant had a form of tunnel vision for which he normally compensated by changing the foreground and background colors and enlarging the text. In the test environment, he enlarged the font significantly and worked with yellow text on a black background. During the test session, this participant made an effort to use JAWS, although this was his first experience with a screen reader. We found that neither of the visually impaired participants was able to complete the form, enter data efficiently and accurately, or navigate efficiently or effectively, even though the site was in compliance with the Section-508 regulations. However, usability goals were met for sighted users.

A lesson learned from this testing is that not all visually impaired users rely on screen readers. In the future, we will ask test participants, in advance of testing, how they prefer to customize the display system and provide their preferred magnification or other software for their use.

In what proved to be a genuine learning experience for the test administrators, my colleagues and I were surprised to learn that a site could be technically accessible, i.e., compliant with legal requirements, but not usable for test participants with disabilities. However, this conclusion is strongly supported by authorities in the fields of accessibility and usability (e.g., Theofanos & Redish, 2003, p. 38): “Meeting the required accessibility standards does not...necessarily mean that a Web site is *usable* for people with disabilities. And if a Web site is not usable, it is not really accessible, even if it has all the elements required by law.”

A process for passing content-related feedback to the survey sponsors and authors is beginning to emerge at the Census Bureau. The overall vision is of a process through which complementary findings come together from iterative cognitive, usability, and accessibility testing and are fed back into the design-and-development process.

3.3.3 Prototyping and Testing an Alternative Design

Navigation of the Census short form can be organized by person or by topic (i.e., item). In the commonly used person-based approach (Figure 1), responses for all items (e.g., name, date of birth, gender, race) are collected for one household member (person), after which the same task is repeated for each successive household member. In the topic-based approach (Figure 2), the participant provides data for a given item (e.g., name) for all persons in the household, and then completes the same task for each successive item (e.g., date of birth, gender, race).

Prior to the formal design and development of an Internet form for the 2005 Census Test, a prototyping effort produced a partly functional version of a topic-based form, which we then tested for usability. The question we explored in testing the topic-based prototype was whether the topic-based approach could be used feasibly to collect data about the U. S. population and households from respondents using the Internet.

User testing of the topic-based prototype was limited to evaluating it for usability, since we were working with only partially functional HTML screens (wireframes), which could not be read by JAWS. The user testing conducted on the topic-based form identified no severe usability issues. Thus, the 2005 Census Internet form will have two versions, a person-based version and a topic-based version, both of which will be evaluated for accessibility as well as usability.

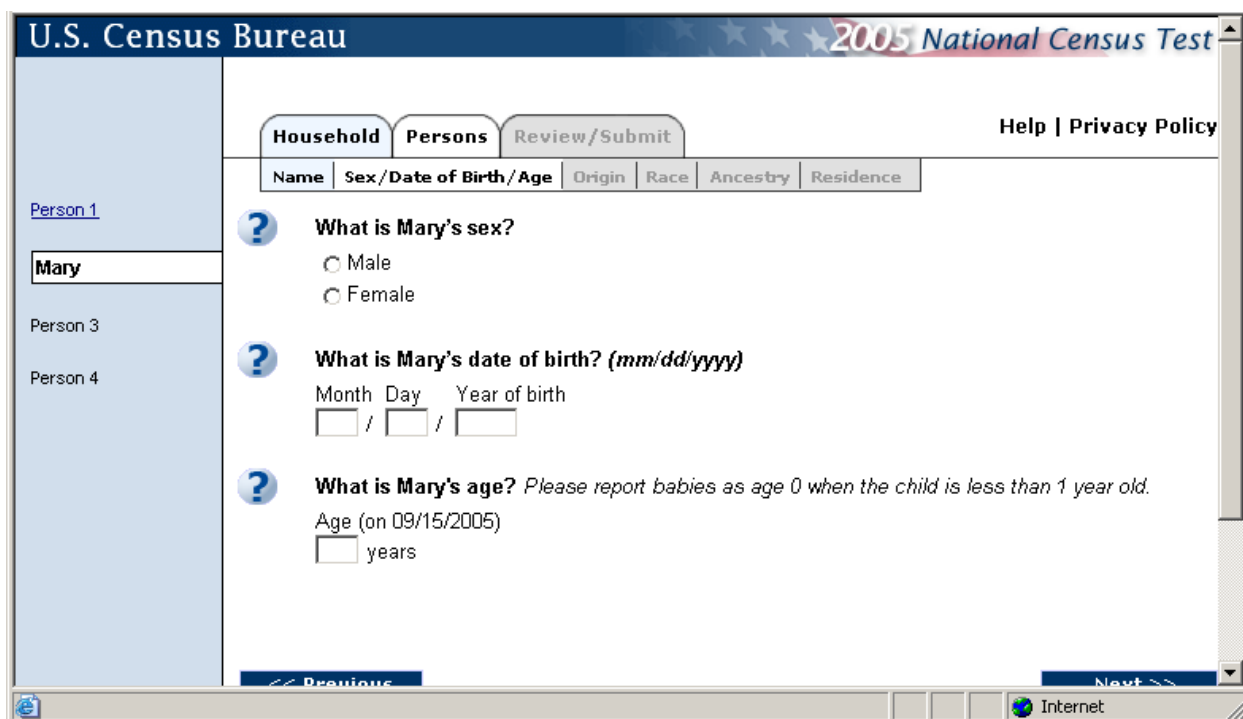


Figure 1. Example of person-based approach to collection of household data.

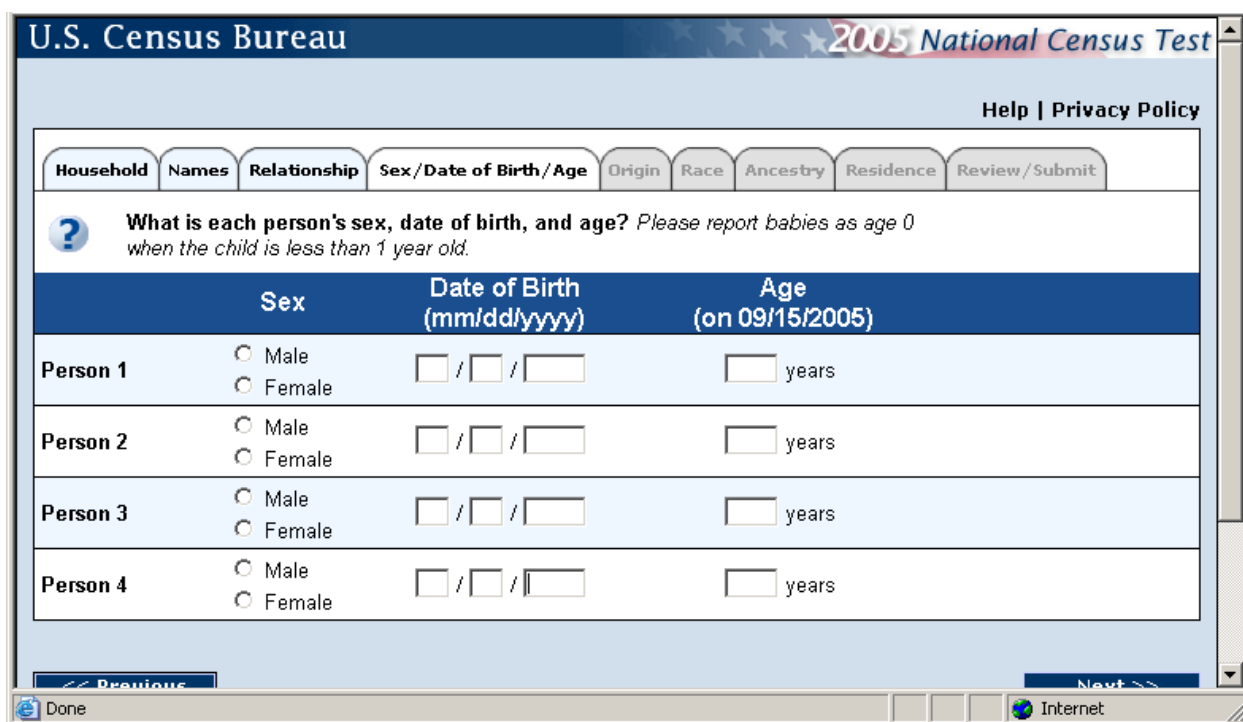


Figure 2. Example of topic-based approach to collection of household data.

3.3.4 Testing during Development and Post-Launch Use

In building the 2005 Census Internet form for testing, the developer followed “best practices” and avoided known accessibility pitfalls such as frames and embedded tables (K. Gold, personal communication, January 2005). Keeping accessibility in mind and following the RUP methodology, the developer first built for the sighted user and then went back to add the tagging needed to comply with the 16 requirements of Section 508. This approach is consistent with the prevalent situation eight years ago, as described by McNally (1996, p. 95): “The current state of software tools does not allow for the development of software...for the disabled market in parallel with the ‘mainstream’ market. Developers usually have to modify existing systems in an ‘ad hoc’ approach to catch up.”

For this round of development, the contractor put together a Section 508 checklist to guide their retrofitting and testing of the 2005 Census Internet form for compliance with Federal regulations. The Census Bureau’s Usability and Accessibility Laboratory also tested the contractor’s software for usability and accessibility. The four rounds of testing for accessibility involved the use of automated tools (i.e., InSight/InFocus and JAWS) as well as the participation of users with various kinds of visual disabilities in three test sessions.

In keeping with the team’s established practice, results from this testing were discussed, and a team decision was made on each identified issue. Changes were made in the software to correct any high-priority violations of usability principles or accessibility regulations. However, there was not sufficient time to software changes made for usability purposes prior to launch. All violations of Section 508 were corrected.

Although two rounds of usability testing had been built into the original schedule, pre-launch testing was cut back to one round to accommodate required security inspections. Instead of a second round of pre-launch testing, we are planning to conduct post-launch testing of alternative design concepts. These studies will inform the identification of requirements for the next design-and-development effort, which will culminate in a major evaluation of the 2008 Census Internet form.

4 Integrating Usability and Accessibility into Online Form Design and Development

The U. S. Census Bureau does not pretend to be an innovator in information technology (IT). As do many other government agencies, the Census Bureau relies on the IT industry to use state-of-the-art processes and procedures in developing software systems, including online questionnaires, for use by our internal personnel and by the general public. The Census Bureau would like a large proportion of those who receive short, paper forms in the 2010 Census to respond online. However, as is well known, current response rates to online, government surveys are hovering at a maximum of 10 percent. Why don’t more people respond electronically when given that option?

We do not have the data to answer that question at present, but we can look at the processes themselves for clues. In general, over the last 20 years, usability has become a fairly well accepted component of the design-and-development lifecycle (cf. Addelston & O’Connell, 2004). That acceptance has been borne out in the extent to which usability has been integrated into design reviews and iterative testing of prototypes at the Census Bureau, not only on the Census Internet project, but on many other data-collection and data-dissemination projects, as well (cf. Murphy, et al., 2001).

Usability has been recognized as a lifecycle component, but the IT industry’s design-and-development processes have not matured to the point where they can be described as “user centered.” At best, they are “usage centered,” focusing on use of the available capabilities by the average person. A fallacy of this approach is that there is no such thing as the average person.

When we begin to think about accessibility, we can see that a usage-centered approach does not consider the many varieties of human capabilities and limitations that will be brought to the interaction with a software user interface. As pointed out by McNulty (1996, p. 96), “For each user group, many factors...must be decided upon...Each group has different needs, abilities, and preferences which must be determined to develop usable systems. The task of gathering these requirements is best completed with user-centered design: by consulting several groups of people,” including the actual users themselves; people who directly interact with the actual users; and those who can communicate the needs of users with disabilities to software developers.

To integrate accessibility into the design-and-development process, the first step is to consider the legal regulations (Section 508) as part of the requirements. But, as we, and others, have seen in usability testing, meeting the legal requirements is not sufficient to provide true accessibility for people with disabilities. What is needed is an approach modelled on the integration of accessibility into the process (e.g., Hix & O'Connell, 2005). A hallmark of this approach is early prototyping of screen designs, based on a clear understanding of users and their tasks, combined with expert review and feedback to the design-and-development process. Low-fidelity prototyping and testing across a wide range of abilities can be a powerful tool for informing design before implementation begins. To review screen designs for accessibility, expert reviewers will need access to whatever markup language is used to provide for accessibility. Meeting this need will require a movement away from early development only for able users to development that provides capabilities for users with disabilities from the beginning. A challenge is to make the benefits of the technology fully available to all users.

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