
| RESEARCH ARTICLE

Accessibility in Mobile and Web-Engineering for Compliance and Inclusion

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| ABSTRACT

This article examines the principles, standards, and implementation strategies for digital accessibility in web and mobile engineering. Through a comprehensive analysis of legal frameworks, technical guidelines, and inclusive design approaches, it demonstrates that accessibility transcends mere compliance to become a core aspect of quality engineering. The paper explores the ethical, business, and legal imperatives driving accessibility adoption, details the technical implementation requirements for both web and mobile platforms, and provides guidance on organizational approaches to accessibility integration. Inclusive design principles, including equivalent experiences, consideration of situational limitations, consistency, and user control, are presented as foundational elements for creating universally accessible digital environments. The benefits of accessibility-first engineering extend beyond compliance to enhance user experience, expand market reach, improve technical quality, foster innovation, and mitigate legal risks. By framing accessibility as an integral component of engineering excellence rather than a specialized accommodation, this article offers a roadmap for creating digital experiences that are inherently inclusive and beneficial for all users.

| KEYWORDS

Digital Accessibility, Inclusive Design, Web Engineering, Mobile Development, Universal Design

| ARTICLE INFORMATION

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1. Introduction: What Is Accessibility and Why Does It Matter?

Digital accessibility refers to the practice of designing and developing websites, mobile applications, and other digital tools to be usable by people with a wide range of abilities and disabilities. This includes individuals with visual, auditory, motor, and cognitive impairments who may interact with digital content through various assistive technologies. The Centers for Disease Control and Prevention's Disability and Health Data System (DHDS) provides critical surveillance information about adults with disabilities, revealing that a substantial portion of adults in the United States have some type of disability [1]. The DHDS employs sophisticated data visualization tools to present disability status across multiple demographics and regions, highlighting that mobility disabilities represent the most common functional disability type among U.S. adults, followed by cognitive disabilities, independent living difficulties, hearing, vision, and self-care challenges. As digital interactions become increasingly central to everyday activities such as education, employment, healthcare, and social connection, the importance of accessibility has grown from a specialized concern to a fundamental engineering principle.

The imperative for accessible design rests on three pillars:

Ethical Imperative: Digital equality represents a fundamental human right. The United Nations Convention on the Rights of Persons with Disabilities (CRPD) explicitly recognizes access to information and communications technologies as essential for full participation in society. Article 9 of the CRPD specifically obligates parties to "promote access for persons with disabilities to new information and communications technologies and systems, including the Internet" and to "promote the design, development, production and distribution of accessible information and communications technologies and systems at an early stage, so that

these technologies and systems become accessible at minimum cost" [2]. The CRPD represents the first comprehensive human rights treaty of the 21st century, having been adopted by the General Assembly in December 2006, opened for signature in March 2007, and entered into force in May 2008. Engineers and product teams have an ethical responsibility to ensure their work does not inadvertently exclude or marginalize users based on ability, aligning with the CRPD's core principles of respect, non-discrimination, full participation, accessibility, and equality of opportunity.

Business Imperative: Accessible design expands market reach and improves user experiences for everyone. Research has found that a significant portion of users with disabilities will immediately leave a website that presents accessibility barriers, taking their business elsewhere. This represents substantial lost revenue annually in markets worldwide. The business case for web accessibility is compelling on multiple levels, as it not only provides access to a wider customer base and helps organizations fulfill their corporate social responsibility commitments, but also delivers concrete business advantages. Accessible websites typically demonstrate improved search engine optimization, reduced maintenance costs, and broader technology compatibility [3]. Well-implemented accessibility features such as proper heading structures and alternative text for images that benefit users with disabilities also significantly improve Google rankings and organic traffic. Furthermore, accessible design principles frequently benefit all users through enhanced usability, improved mobile experiences, and support for diverse usage contexts.

Legal Imperative: An increasing number of jurisdictions worldwide have established legal frameworks requiring digital accessibility. Organizations face financial penalties, reputational damage, and litigation risks for non-compliance. Digital accessibility lawsuits have shown a steady upward trend, with federal cases increasing consistently year over year. The most impacted industries include retail, food service, consumer services, travel/hospitality, and banking/financial services [4]. The Americans with Disabilities Act (ADA) remains the primary vehicle for digital accessibility litigation in the United States, though state laws and international regulations continue to evolve. New York, California, and Florida continue to be the states with the highest volume of case filings, while emerging trends show increased focus on specific types of digital experiences such as mobile applications, video content accessibility, and overlays. Organizations should note that having accessibility statements or using certain tools does not provide immunity from litigation if barriers to access remain present.

This paper examines the technical foundations, implementation strategies, and organizational approaches needed to achieve meaningful accessibility in digital engineering. We argue that accessibility should be understood not as a separate technical requirement but as an integral aspect of quality engineering that enhances products for all users.

Imperative	Key Frameworks	Organizational Benefits
Ethical	CRPD Article 9, Universal design principles	Social responsibility, Inclusive brand values
Business	Market research, UX metrics	Expanded customer base, Enhanced usability
Legal	ADA, Section 508, EAA, AODA	Reduced litigation risk, Procurement eligibility

Table 1: The Three Pillars of Accessibility [4]

2. Core Standards and Legal Frameworks

2.1 Web Content Accessibility Guidelines (WCAG)

The Web Content Accessibility Guidelines, developed by the World Wide Web Consortium's (W3C) Web Accessibility Initiative, represent the most comprehensive and widely adopted framework for digital accessibility. Currently in version 2.1 (with WCAG 2.2 and 3.0 in development), these guidelines are organized around four core principles, often referred to by the acronym POUR: Perceivable, Operable, Understandable, and Robust. The CDC's Disability and Health Data System demonstrates the real-world necessity of these guidelines by providing detailed state-level data about functional disability types that directly correspond to WCAG requirements [1]. For example, vision disability data collected through the DHDS highlights why perceivable requirements like text alternatives and adaptable content are essential, while data on mobility disabilities underscores the importance of keyboard accessibility under the operable principle.

The CRPD further reinforces the importance of these technical standards through its promotion of "Universal Design," which it defines as "the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [2]. This aligns perfectly with WCAG's goal of making web content accessible to a wider range of people with disabilities, including blindness and low vision, deafness and hearing loss, learning disabilities, cognitive limitations, limited movement, speech disabilities, and combinations of these. WCAG's structured approach provides three conformance levels (A, AA, and AAA), with Level AA being the most commonly referenced standard in legal and regulatory requirements.

Level	Description	Common Applications
A	Minimum level addressing critical barriers	Basic websites, simple applications
AA	Addresses common barriers; most widely required	Corporate websites, e-commerce, educational platforms
AAA	Highest level for specialized accessibility needs	Healthcare applications, government services

Table 2: WCAG Conformance Levels [2]

2.2 Legal Frameworks

Accessibility legislation varies globally but increasingly references WCAG as a technical standard. The Americans with Disabilities Act (ADA) serves as a foundational legal framework in the United States, though it predates widespread internet adoption. The Department of Justice has consistently maintained that the ADA applies to websites and digital services. Section 508 of the Rehabilitation Act establishes requirements for federal agencies and their contractors. The comprehensive litigation tracking provided in the Digital Accessibility Lawsuit Report reveals that large retailers, supermarkets, and department stores face the highest number of federal cases, followed closely by restaurants/dining establishments [4]. This likely reflects both the high public engagement with these services and their essential nature in daily life.

The European Union has established the European Accessibility Act (EAA) and Web Accessibility Directive, which require public sector websites and applications to conform to WCAG 2.1 Level AA standards. The United Kingdom enforces accessibility through the Equality Act, which requires service providers to make "reasonable adjustments" for people with disabilities. Canada has enacted the Accessibility for Ontarians with Disabilities Act (AODA) and more recently the Accessible Canada Act, both of which incorporate WCAG standards. These regulations align with Article 9 of the CRPD, which establishes that States Parties "shall take appropriate measures to ensure to persons with disabilities access, on an equal basis with others, to the physical environment, to transportation, to information and communications, including information and communications technologies and systems, and to other facilities and services open or available to the public" [2].

The business implications of these legal frameworks extend beyond compliance costs. Organizations implementing accessibility proactively gain significant advantages in reduced legal exposure and improved brand reputation. Recent research indicates that companies with robust accessibility practices experience measurable benefits in customer loyalty, with studies showing that consumers increasingly prefer to support businesses that demonstrate inclusive values [3]. Additionally, organizations with accessible digital platforms report advantages in recruitment and retention of employees with disabilities, further enhancing workforce diversity and organizational performance.

3. Engineering for Accessibility: Web and Mobile

3.1 Web Accessibility Implementation

Effective web accessibility implementation requires attention to structure, interaction, and content. The CDC's Disability and Health Data System serves as an excellent example of accessible data visualization, providing interactive maps, charts, and data tables that follow WCAG principles [1]. The system employs robust semantic structure with proper headings, descriptive labels, and alternative text for graphical elements, ensuring that public health information about disability demographics is accessible to all users, including those with disabilities.

Feature	Web	Mobile
Semantic Structure	HTML5 elements, ARIA landmarks	Platform accessibility APIs, Proper labeling
Input Methods	Keyboard focus, Tab order	Touch targets, Simple gestures
Visual Design	Color contrast, Responsive design	Dynamic text sizing, Device orientation
Media	Captions, Transcripts	Platform media players, Integrated features

Table 3: Web vs. Mobile Accessibility Implementation [1]

3.1.1 Semantic Structure

The foundation of accessible web engineering is proper semantic HTML, which provides meaning and context to content. This approach directly supports the CRPD's emphasis on access to information and communication technologies [2]. By using appropriate heading structures, landmark regions, and HTML elements that convey their purpose and relationship to other content, developers create experiences that are navigable and understandable by assistive technologies. Semantic markup is particularly important for complex applications like the DHDS, which contains data filters, interactive elements, and dynamic content.

When HTML elements do not inherently convey the necessary semantics, Accessible Rich Internet Applications (ARIA) attributes can supplement native semantics. However, developers should prefer native HTML semantics when available and use ARIA only when necessary, as improper implementation can create additional barriers rather than removing them.

Organizations implementing proper semantic structures report significant improvements in both accessibility outcomes and general user experience metrics. The business case for proper semantic structure extends beyond accessibility compliance, as it also improves search engine optimization, enhances mobile responsiveness, and simplifies maintenance [3]. This multi-benefit approach demonstrates why accessibility implementation should be viewed as a quality engineering practice rather than merely a compliance requirement.

3.1.2 Keyboard Accessibility

Keyboard accessibility is essential for users with mobility disabilities, which the DHDS indicates is the most common functional disability type among adults in the United States [1]. Core keyboard accessibility requirements include proper focus management, visible focus indicators, and avoidance of keyboard traps. These implementations directly support the CRPD's call for technologies to be accessible from early stages of development [2].

Proper keyboard accessibility involves techniques such as maintaining logical tab order, ensuring all interactive elements are keyboard operable, providing visible focus states, and managing focus during dynamic interactions like modal dialogs and form submissions. These practices ensure that users who cannot use pointing devices can still navigate and interact with digital content effectively.

Litigation data indicates that keyboard accessibility issues are frequently cited in digital accessibility lawsuits, with navigation barriers being among the most common complaints [4]. Organizations implementing robust keyboard accessibility not only reduce legal exposure but also facilitate access for a variety of users beyond those with disabilities, including power users who prefer keyboard shortcuts and individuals using mobile devices with external keyboards.

3.1.3 Visual Design Considerations

Accessibility extends to visual presentation, particularly regarding color usage and typography. The DHDS indicates that vision disability affects a significant portion of adults, necessitating attention to color contrast, text size, and layout considerations [1]. WCAG requires a minimum contrast ratio for text, prohibits conveying information by color alone, and ensures content remains functional when text is resized.

These visual design considerations align with the CRPD's broader principle of universal design, which aims to produce environments, products, and services usable by all people without the need for specialized adaptation [2]. Organizations implementing accessible visual design often report improvements in general user experience metrics and brand perception, as enhanced readability and clear visual hierarchies benefit all users regardless of ability status [3].

3.2 Mobile Accessibility Implementation

Mobile applications present unique accessibility challenges compared to web applications, requiring specialized approaches. Digital accessibility lawsuits addressing mobile applications have increased in recent years, demonstrating the growing importance of addressing accessibility across all digital platforms [4].

3.2.1 Platform-Specific Accessibility APIs

Both major mobile platforms provide robust accessibility frameworks through their respective accessibility APIs. On iOS, VoiceOver works with the UIAccessibility protocol to provide screen reading capabilities, while Android offers TalkBack alongside its AccessibilityNodeInfo framework. These platforms require developers to implement proper accessibility properties including labels, hints, traits or descriptions, and proper role information.

These implementations directly support the goals outlined in the CRPD, particularly Article 9's mandate to "promote the design, development, production and distribution of accessible information and communications technologies and systems at an early stage" [2]. By incorporating accessibility at the API level, developers ensure that assistive technologies can provide meaningful experiences to users with disabilities.

3.2.2 Mobile-Specific Considerations

Several factors are particularly important for mobile accessibility:

Touch Target Size: Interactive elements should have an appropriate minimum touch target size on iOS or density-independent pixels on Android. This directly addresses the needs of users with mobility disabilities, which the DHDS identifies as the most prevalent functional disability type [1].

Gesture Alternatives: Complex gestures must have simpler alternatives, supporting the CRPD's principle of ensuring "access, on an equal basis with others" [2]. This consideration is particularly important for users with motor control limitations.

Device Orientation: Content should function in both portrait and landscape orientations, providing flexibility for users with different mounting or holding requirements.

Screen Size Adaptation: Layouts must adapt gracefully to different screen sizes, supporting the diversity of devices and display preferences.

The business case for mobile accessibility is particularly compelling given the dominance of mobile devices in global internet usage. Organizations implementing accessible mobile experiences report higher user engagement, increased conversion rates, and broader market reach [3]. Additionally, many mobile accessibility features, such as clear touch targets and flexible layouts, represent good design practices that benefit all users regardless of ability status.

4. Inclusive Design Principles

Inclusive design extends beyond technical compliance to embrace a set of principles that guide the creation of universally accessible experiences. These principles establish a foundation for creating truly equitable digital products. The Section 508 initiative emphasizes that accessible technology often results in better products for everyone, creating improved user interfaces and more flexible designs that meet diverse user needs under various circumstances. This approach aligns with universal design concepts where products and environments are designed to be usable by all people to the greatest extent possible without the need for adaptation or specialized design [5]. The benefits extend well beyond compliance, as implementing accessibility standards can save resources by reducing duplication of effort, ensuring compatibility across systems, and future-proofing applications against evolving technology and user requirements.

4.1 Provide Equivalent Experiences

Different users may access content through various modalities, but the core experience and information should remain equivalent. Research on user experience and web accessibility demonstrates that accessible design patterns significantly enhance usability for all users, not just those with disabilities. The relationship between user experience (UX) and accessibility is complementary rather than contradictory, as both disciplines share fundamental goals of creating usable interfaces [6]. Though they evolved from different backgrounds—UX from human-computer interaction and accessibility from disability rights—both aim to improve how humans interact with technology. When interfaces provide robust alternatives for multimedia content, they serve not only users with permanent disabilities but also those facing temporary or situational limitations.

For example, video content requires captions and audio descriptions to serve users with hearing or visual impairments. Interactive data visualizations should provide accompanying data tables as alternatives for screen reader users. Critical notifications must employ multiple sensory channels—visual, auditory, and haptic—to ensure information reaches all users regardless of their sensory capabilities. The Microsoft Disability Answer Desk playbook highlights that providing equivalent experiences is fundamental to inclusive customer service and product design. Their approach centers on meeting customers where they are, ensuring all support channels are fully accessible, and recognizing that people with disabilities are not a homogeneous group but have diverse needs requiring thoughtful, multifaceted solutions [7]. The playbook emphasizes that designing for disability scenarios often results in solutions that benefit all users, creating a more intuitive and adaptable experience regardless of ability.

Principle	Key Components	Implementation Examples
Equivalent Experiences	Multiple modalities	Video captions, Chart alternatives
Situational Limitations	Temporary & situational impairments	Voice control, High contrast modes
Consistency	Navigation, Terminology, Interaction patterns	Persistent elements, Standard behaviors

Principle	Key Components	Implementation Examples
User Control	Timing, Motion, Content presentation	Pause controls, Text sizing options

Table 4: Inclusive Design Principles [7]

4.2 Consider Situational Limitations

Accessibility features benefit users across a spectrum of abilities and situations—permanent, temporary, and situational. The same design decisions that help users with permanent disabilities also benefit users experiencing temporary impairments, situational limitations, or device constraints. The concept of situational disability recognizes that disability is contextual and can affect anyone under certain circumstances. When someone tries to use a mobile device while walking or in bright sunlight, they experience a form of situational disability that makes accessing digital content more challenging [8]. Environmental factors such as noise, glare, distraction, or physical constraints can create barriers similar to those experienced by individuals with permanent disabilities. For instance, captioning assists not only deaf users but also anyone watching video in a noisy environment, while voice control benefits both individuals with motor impairments and someone whose hands are occupied with other tasks.

4.3 Be Consistent and Predictable

Consistency reduces cognitive load and helps users build accurate mental models of how interfaces work. This principle is especially important for users with cognitive disabilities but benefits everyone by reducing the mental effort required to navigate digital environments. Research on cognitive accessibility identifies several key barriers that inconsistent interfaces create for users, including excessive cognitive load, memory demands, and attention requirements [9]. When interfaces lack consistency in navigation, terminology, or interaction patterns, users must constantly reorient themselves and relearn how to accomplish tasks. For people with cognitive impairments, this additional processing can make the difference between being able to use a digital product independently or requiring assistance. Consistency supports users with autism spectrum disorders, attention deficit conditions, dyslexia, and intellectual disabilities by creating reliable patterns they can learn once and apply throughout the interface.

The implementation of consistent patterns should extend across navigation mechanisms, which must remain in predictable locations; terminology, using the same terms for the same concepts throughout the interface; and interaction patterns, ensuring similar actions work similarly across the interface. Literature on cognitive accessibility emphasizes that predictability is fundamental to creating inclusive digital environments. When users can anticipate how an interface will respond to their actions, they develop confidence and competence in using digital systems. This predictability is especially valuable for users with learning disabilities, memory impairments, or executive function challenges [9].

4.4 Give Control to the User

Accessible interfaces provide users with control over how they interact with content. The principle of user control acknowledges the diversity of human needs and preferences, allowing individuals to customize their experiences. The Section 508 standards recognize that providing users with control over interface elements creates not just more accessible experiences but also more satisfying ones for all users [5]. When users can adjust timing, control motion, and modify content presentation, they can optimize the interface to match their specific needs and preferences. These adaptations are essential for people with disabilities but often enhance the experience for everyone. For example, the ability to increase text size benefits users with visual impairments, but also helps anyone using a small screen or reading in low-light conditions.

Key aspects of user control include adjustable timing, allowing users to disable, adjust, or extend time limits; control over motion, providing mechanisms to reduce or eliminate animation and motion; and content control, enabling users to adjust text size, spacing, and contrast. User preference media queries have emerged as a powerful technical approach for respecting user control. These queries enable websites to detect and respond to user-defined system preferences, such as reduced motion or high contrast modes, automatically adjusting the presentation to match individual needs. By implementing these technologies, developers can create experiences that adapt to user requirements without requiring additional configuration within each application [6].

5. Practical Implementation Strategies

5.1 Testing and Validation

Effective accessibility implementation requires comprehensive testing strategies that incorporate automated tools, manual expert review, and user testing. The Section 508 implementation guidance emphasizes a multi-faceted approach to testing, recognizing that no single method can identify all potential accessibility issues [5]. A comprehensive testing strategy helps organizations identify barriers early in the development process when they are less expensive to remediate, and provides a more complete

picture of the user experience for people with disabilities. Testing should be viewed not as a one-time verification process but as an integral part of the development lifecycle, with accessibility considerations embedded at every stage.

5.1.1 Automated Testing

Automated tools provide an efficient first line of defense for identifying accessibility issues, though they cannot detect all potential barriers. The relationship between user experience testing and automated accessibility evaluation shows that both approaches have complementary strengths and limitations [6]. Automated tools excel at detecting technical violations that can be programmatically verified, such as missing alternative text, insufficient color contrast, and improper heading structures. However, they cannot effectively evaluate subjective aspects of accessibility such as the appropriateness of alternative text, the logical ordering of content, or the overall usability of accessible features. Despite these limitations, automated testing remains an essential component of accessibility validation, providing a cost-effective way to identify many common issues.

Method	Strengths	Limitations
Automated	Technical violations, CI/CD integration	Cannot evaluate subjective quality
Manual Expert	Navigation flows, Screen reader compatibility	Time-intensive, Expertise-dependent
User Testing	Real-world usage, Subjective feedback	Resource-intensive, Scheduling challenges

Table 5: Accessibility Testing Methods [6]

Organizations should integrate automated accessibility testing into continuous integration/continuous deployment (CI/CD) pipelines. This integration allows teams to identify and address accessibility issues as part of their regular development workflow rather than treating accessibility as a separate concern addressed only at the end of the development process. Popular automation tools include axe-core for programmatic testing, Lighthouse for web application testing, Accessibility Insights for comprehensive workflows, XCTest Accessibility for iOS applications, and Espresso for Android applications. While these tools vary in their coverage and approach, they all help developers identify potential accessibility barriers early in the development process when remediation is most efficient [5].

5.1.2 Manual Testing

Manual testing protocols should supplement automated testing by focusing on aspects that automated tools cannot effectively evaluate. The Microsoft Disability Answer Desk playbook emphasizes the importance of hands-on testing with assistive technologies to understand the actual user experience [7]. This approach recognizes that technical compliance with accessibility standards, while necessary, does not guarantee a usable experience for people with disabilities. Manual testing puts developers and testers in the position of assistive technology users, helping them identify issues that might otherwise go undetected until after release. This type of empathetic testing builds understanding of accessibility challenges and fosters a more inclusive mindset among development teams.

Comprehensive manual testing protocols should include keyboard testing, verifying all functionality works with keyboard alone; screen reader testing with popular screen readers including NVDA and JAWS (Windows), VoiceOver (macOS/iOS), and TalkBack (Android); magnification testing, verifying usability at various zoom levels; color and contrast analysis, verifying both with tools and through simulation; and cognitive testing, evaluating forms, instructions, and error messages for clarity. These diverse testing approaches help identify different types of barriers that might affect various user groups, providing a more complete picture of accessibility than any single testing method could offer [6].

5.1.3 User Testing

Testing with actual users of assistive technologies provides the most valuable feedback. The Microsoft Disability Answer Desk's approach emphasizes direct engagement with the disability community as essential to creating truly accessible experiences [7]. This engagement goes beyond testing to include ongoing dialogue, feedback mechanisms, and collaborative problem-solving. By involving people with disabilities throughout the development process, organizations gain insights that no amount of technical testing can provide. Users with disabilities bring their lived experience to the testing process, identifying not just technical barriers but also usability concerns, workflow issues, and opportunities for innovation that might otherwise be overlooked.

Effective user testing protocols should include participants with diverse disabilities, test core user journeys rather than isolated components, combine observation with structured feedback, and compensate participants appropriately for their expertise. The situational disability perspective reminds us that testing should consider not just permanent disabilities but also temporary and situational limitations that might affect users in various contexts [8]. This broadened perspective helps create more flexible, adaptable interfaces that work well across a wide range of scenarios, benefiting all users regardless of their ability status.

5.2 Organizational Implementation

5.2.1 Accessibility Champions Model

The distributed expertise model identifies and develops accessibility champions throughout the organization. This approach has demonstrated significant advantages over centralized accessibility teams. The Section 508 implementation guidance recommends establishing clear roles and responsibilities for accessibility throughout the organization, with leadership commitment, designated coordinators, and embedded expertise in product teams [5]. This distributed model ensures that accessibility is everyone's responsibility rather than being siloed within a specialized team. By cultivating expertise across departments and disciplines, organizations can address accessibility considerations at every stage of product development and maintenance.

The most effective implementations of this model include executive sponsors providing strategic direction and resources, accessibility leads coordinating organization-wide initiatives, team champions embedded within product teams, and practice champions specialized in design, development, content, and testing. The Microsoft Disability Answer Desk playbook highlights the importance of accessibility champions who serve as advocates, educators, and resources for their colleagues [7]. These champions help raise awareness, build skills, and maintain focus on accessibility throughout the organization. They also serve as bridges between different teams, facilitating communication and knowledge sharing about accessibility best practices and emerging challenges.

Model	Structure	Best For
Centralized	Dedicated accessibility team	Organizations beginning accessibility journey
Distributed Champions	Embedded experts with central coordination	Large enterprises, Multiple product lines
Fully Integrated	Accessibility in all roles	Organizations with mature practices

Table 6: Organizational Implementation Models [7]

5.2.2 Integration in Development Lifecycle

Accessibility considerations must be integrated at every stage of the development lifecycle. Research on user experience and accessibility standards emphasizes that accessibility should not be treated as a separate concern addressed only at the end of development [6]. Instead, it should be woven into existing processes for requirements gathering, design, development, testing, and maintenance. This integrated approach ensures that accessibility is considered from the earliest stages of product conceptualization through implementation and beyond, reducing the need for expensive remediation later in the process. By making accessibility part of the definition of quality for all digital products, organizations build it into their culture and processes rather than treating it as an optional add-on.

Key integration points include planning, design, development, quality assurance, deployment, and monitoring. At each stage, specific accessibility considerations must be addressed to ensure the final product meets both technical standards and user needs. For example, planning should include explicit accessibility requirements based on user research and standards; design should incorporate accessible patterns and be validated against accessibility guidelines; development should implement according to standards and include ongoing testing; quality assurance should include specific accessibility test cases; deployment should validate accessibility before release; and monitoring should include accessibility metrics in production monitoring [5]. This comprehensive approach ensures that accessibility isn't forgotten or deprioritized at any stage of development.

6. The Benefits of Accessibility-First Engineering

The adoption of accessibility-first engineering yields measurable benefits beyond compliance, creating value across multiple business dimensions. The Section 508 initiative outlines numerous advantages to implementing accessibility, including expanding market reach, enhancing brand image, driving innovation, and reducing maintenance costs [5]. These benefits make a compelling business case for accessibility as a strategic investment rather than merely a compliance requirement. Organizations

that embrace accessibility as a core value find that it not only fulfills their ethical and legal obligations but also creates competitive advantages in the marketplace.

6.1 Enhanced User Experience and Market Reach

Accessible design improves experiences for all users, driving measurable improvements in engagement and conversion metrics. Research on user experience and accessibility confirms that well-implemented accessibility features enhance usability for everyone, not just people with disabilities [6]. Features like clear navigation, descriptive links, proper heading structures, and keyboard accessibility create more intuitive, efficient interfaces for all users. This improved usability leads to higher engagement, lower bounce rates, and better conversion metrics across the board. By designing for the full spectrum of human ability, organizations create products that work better in a wider range of contexts for a broader audience.

The market reach implications are substantial. The Section 508 guidance notes that accessible design expands an organization's potential customer base by making products usable by people with disabilities, who collectively represent a significant market segment with substantial purchasing power [5]. Additionally, many accessibility features benefit older adults, who control a disproportionate share of disposable income in many economies. By making digital products accessible, organizations tap into these valuable market segments while also creating more usable experiences for their existing customers. This expanded reach represents not just a social good but a significant business opportunity.

Many accessibility practices directly improve mobile experiences. The situational disability framework highlights how mobile users frequently encounter contextual limitations similar to those experienced by people with permanent disabilities [8]. For example, someone using a mobile device in bright sunlight experiences visual challenges similar to those faced by users with low vision; someone in a loud environment has hearing limitations analogous to those of deaf users; and someone using a phone one-handed has temporary motor limitations like those experienced by users with certain physical disabilities. By designing for accessibility, organizations simultaneously address these situational challenges, creating mobile experiences that work better across a wide range of contexts.

User Experience	<i>Improved usability, Enhanced satisfaction</i>	<i>Increased loyalty, Higher conversion rates</i>
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Table 7: Benefits of Accessibility-First Engineering [8]

6.2 Technical Quality and Innovation

Accessibility drives engineering excellence, leading to higher-quality code and more innovative solutions. The Section 508 initiative notes that implementing accessibility standards often results in more modular, maintainable code with clearer separation of content and presentation [5]. These technical quality improvements benefit all aspects of the application, not just its accessibility features. For example, properly structured semantic HTML that benefits screen reader users also improves SEO performance, device compatibility, and future maintainability. By following accessibility best practices, development teams create more robust, future-proof applications that work better across platforms and devices.

Organizations with mature accessibility practices also report significant maintenance benefits. The Section 508 resources highlight that building accessibility in from the beginning reduces the need for costly retrofitting later in the product lifecycle [5]. This proactive approach not only saves direct remediation costs but also reduces the disruption and technical debt that often accompany last-minute accessibility fixes. Additionally, accessible applications tend to work better with future technologies and emerging platforms due to their adherence to standards and focus on interoperability. This forward compatibility reduces the need for major overhauls when new devices or interaction methods emerge.

Perhaps most importantly, accessibility constraints have historically driven significant innovations that benefit all users. The Section 508 initiative acknowledges that designing for edge cases often leads to breakthroughs that improve the experience for everyone [5]. Technologies including text-to-speech, voice recognition, keyboard shortcuts, captioning, and situational awareness all began as accessibility solutions before finding mainstream adoption. By embracing the creative constraints that accessibility requirements impose, organizations often discover new approaches and solutions that differentiate their products

and create competitive advantages. This innovation potential represents a significant but often overlooked benefit of accessibility-first engineering.

6.3 Legal Risk Mitigation

A proactive accessibility approach substantially reduces legal exposure, providing significant risk management benefits. The Section 508 implementation guidance acknowledges that accessibility is increasingly becoming a legal requirement for many organizations, with an expanding framework of laws and regulations at the federal, state, and international levels [5]. By implementing accessibility proactively, organizations reduce their exposure to complaints, litigation, and regulatory action. This risk mitigation represents a substantial business benefit, as the costs of accessibility-related legal issues can be significant, including not just direct settlement or judgment amounts but also legal fees, remediation expenses, and organizational disruption.

The reputational implications of accessibility litigation extend beyond direct legal costs. The Microsoft Disability Answer Desk playbook emphasizes that organizations seen as excluding people with disabilities face significant brand damage in today's socially conscious marketplace [7]. Conversely, companies recognized as leaders in accessibility often enjoy enhanced brand perception and customer loyalty. This reputational impact affects not just consumer perception but also employee recruitment and retention, investor relations, and partnership opportunities. By embracing accessibility as a core value, organizations position themselves as forward-thinking, inclusive, and socially responsible—attributes increasingly valued by all stakeholders.

Accessibility compliance also creates procurement advantages, particularly for organizations selling to government or enterprise customers. The Section 508 initiative notes that many public and private sector organizations now include explicit accessibility requirements in their procurement processes [5]. This trend means that vendors unable to demonstrate accessibility compliance may be excluded from significant market opportunities, particularly in government contracting, education, healthcare, and financial services. By building accessibility into their products, organizations ensure they remain eligible for these important contracts and partnerships. This competitive advantage can be substantial, especially in industries where government and enterprise clients represent major revenue sources.

7. Future Directions

Accessibility in mobile and web engineering represents both a compliance requirement and a framework for inclusive innovation. By implementing accessibility standards and inclusive design principles, engineering teams create digital experiences that are more robust, equitable, and ultimately more successful. Looking forward, several key areas deserve focused research and development attention.

The impact of emerging technologies such as AI-generated content, virtual reality, and voice interfaces on accessibility standards and practices requires careful examination. The literature on cognitive accessibility highlights particular concerns about how these new modalities might affect users with cognitive differences [9]. AI-generated content, while promising for certain accessibility applications like automated captioning or image description, may not adequately address the needs of users with cognitive disabilities without careful design and testing. Virtual reality presents challenges for users with a range of disabilities, from motion sensitivity to cognitive orientation issues. Voice interfaces, while potentially revolutionary for some users with disabilities, may present barriers for others, including people with speech differences, cognitive processing challenges, or hearing impairments. These emerging technologies require thoughtful accessibility consideration to ensure they enhance rather than hinder digital inclusion.

Methods for quantifying the return on investment for accessibility initiatives beyond compliance metrics represent another critical research direction. The Section 508 resources outline various benefits of accessibility but acknowledge the challenge of quantifying these advantages in financial terms [5]. Current models typically focus on risk reduction and compliance costs rather than capturing the full business value of inclusive design. More comprehensive approaches are needed to measure and communicate the complete value proposition of accessibility investments, including enhanced user satisfaction, expanded market reach, improved brand perception, and innovation acceleration. By developing more robust ROI models, advocates can make a stronger business case for accessibility investments, helping shift organizational perception from viewing accessibility as a cost center to recognizing it as a value driver.

Strategies for incorporating accessibility into agile development methodologies without sacrificing speed remain challenging for many organizations. The user experience and accessibility standards research suggests that integrating accessibility into existing workflows rather than treating it as a separate concern can help address this challenge [6]. Approaches such as incorporating accessibility user stories, including accessibility in definition of done criteria, and employing accessibility champions within agile teams show promise for maintaining development velocity while ensuring accessibility needs are addressed. As agile methodologies continue to evolve, finding effective ways to integrate accessibility testing and remediation into sprint cycles represents an important area for ongoing research and experimentation.

Approaches for standardizing mobile accessibility testing across diverse devices and platform versions represent a particular challenge given the fragmentation of the mobile ecosystem. The situational disability framework suggests that mobile testing should consider not just technical compliance but also the varied contexts in which mobile devices are used [8]. Effective testing strategies must account for different screen sizes, input methods, platform versions, and usage environments. Developing efficient testing protocols that provide adequate coverage without becoming prohibitively time-consuming or resource-intensive represents an important area for future research. This challenge is particularly significant given the rapid evolution of mobile devices and the growing importance of mobile-first digital experiences.

As digital experiences become increasingly central to everyday life, the imperative for accessible design grows stronger. Engineering for accessibility is not merely a specialized discipline but a core aspect of quality digital engineering that benefits users across the full spectrum of human ability. The cognitive accessibility literature emphasizes that creating truly inclusive digital environments requires ongoing commitment, research, and innovation [9]. By embracing this commitment, organizations position themselves for both ethical leadership and business advantage in an increasingly digital world. The future of accessibility engineering lies not just in compliance with existing standards but in pushing boundaries to create more inclusive, adaptable, and empowering digital experiences for everyone.

Conclusion

Accessibility in mobile and web engineering represents both a fundamental requirement and a strategic opportunity for organizations developing digital products. By implementing established standards and embracing inclusive design principles, engineering teams create experiences that are more robust, equitable, and ultimately more successful in the marketplace. The integration of accessibility considerations throughout the development lifecycle yields measurable benefits across multiple dimensions, from expanded market reach and enhanced brand reputation to improved code quality and reduced maintenance costs. As digital interactions become increasingly central to everyday activities, the imperative for accessible design grows stronger. The future of digital accessibility lies not merely in compliance with current standards but in pioneering new approaches that push the boundaries of inclusion. Through continued innovation in testing methodologies, development practices, and emerging technologies, the field will continue to evolve toward digital experiences that seamlessly accommodate the full spectrum of human abilities and contexts. Accessibility should be understood not as a specialized discipline but as an essential aspect of quality engineering that benefits all users while ensuring digital environments remain open and equitable for everyone.

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