Systematically Evaluating Equivalent Purpose for Digital Maps

Abstract

Digital geographic maps remain largely inaccessible to blind and low-vision individuals (BLVIs), despite global legislation adopting the Web Content Accessibility Guidelines (WCAG). A critical gap exists in defining "equivalent purpose" for maps under WCAG Success Criterion 1.1.1, which requires that non-text content provide a text alternative that serves the "equivalent purpose". This paper proposes a systematic framework for evaluating map accessibility, called the Map Equivalent-Purpose Framework (MEP Framework), defining purpose through three items (Generalized, Spatial Information, and Spatial Relationships), and establishing 15 measurable criteria for equivalent information communication. Eight text map representations: turn-by-turn directions, tables, Nearby Address Searches, short text alternatives, Google Maps Interactive Alternate Text, Audiom Map Interactive Alternate Text, Multi User Domain (MUD) Maps, and audio descriptions, were evaluated against visual map baselines using the proposed MEP Framework. Results show that legacy methods such as tables and turn-by-turn directions fail to meet the MEP Framework criteria, while Audiom Maps, MUD Maps, and Audio Descriptions meet the criteria. The evaluation highlights the necessity of holistic, systematic approaches to ensure non-visual maps convey all generalized spatial information and relationships present in visual maps. A successful text map representation needs to have the functionality to convey every area of the framework, either through an interactive embodied approach (e.g., keyboard presses, touchscreen-based, or other controller based), or structured description. The MEP Framework provides a replicable methodology for assessing digital map accessibility, clarifying WCAG's equivalent purpose, and guiding compliant and usable map

creation. Compliant maps will support BLVIs' participation in map-dependent professions and civic engagement.

Keywords

Map, GIS, WCAG, Cartography, Accessibility, Alternate Text

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Introduction

While the *Web Content Accessibility Guidelines (WCAG) Overview* are becoming part of global digital accessibility legislation (U.S. Department of Justice Civil Rights Division; W3C Web Accessibility Initiative), ambiguity exists, particularly around digital geographic map accessibility (Biggs, Coughlan, et al.; Sloan; KMSOC). This paper proposes a systematic definition and evaluation framework, called the Map Equivalent-Purpose Framework (MEP Framework), in order to determine if blind and low vision individuals (BLVIs) can equally obtain the same information as their sighted counterparts from digital geographic maps. WCAG success criterion (SC) 1.1.1 states: "non-text content that is presented to the user has a text alternative that serves the equivalent purpose", but what does "*equivalent purpose*" mean for geographic maps (World Wide Web Consortium)? According to the World Wide Web consortium (W3C) technique G92, there is a three-part test to determine equivalent purpose for WCAG SC1.1.1: "(1) Remove, hide, or mask the non-text content; (2) Display the long description; and (3) Check that the long description conveys the same information conveyed by the non-text content" (Accessibility Guidelines Working Group). Note although the longDesc element is deprecated in HTML, the following tutorial outlines other methods of providing long descriptions, including by using the figcaption element and or a link to another page (W3C Web Accessibility Initiative). The intent behind SC1.1.1. is clear, but with the numerous existing interpretations of this criterion around maps, a structured evaluation framework is needed (Minnesota IT Services; Sloan; Logan, *Accessible Maps on the Web*). The proposed MEP Framework consists of a three-part framework for defining purpose, and a 15-part framework for defining equivalent information communication. For an equivalent purpose to be achieved-as compared to a non-text map baseline-all the criteria from both parts of the MEP Framework need to be satisfied.

Guidance from the web accessibility community has provided five general techniques for making text maps: turn-by-turn directions (Sloan); nearby address searches (*PO Locator*; *AirNow*); a list of locations (Shull; Logan, *Accessible Maps on the Web*; Juan-Armero and Luján-Mora); alternate text (Minnesota IT Services; McCall and Chagnon; Cassidy); or tables (Sloan; *United States COVID-19 Cases, Deaths, and Laboratory Testing (NAATs) by State, Territory, and Jurisdiction*). These methods, however, tend to focus on qualitative aspects of the map experience, or defining the *primary* purpose of the map, which is different from providing the equivalent purpose as defined by WCAG above. There are other empirically tested and or co-designed research-based text map techniques:

- Interactive alternate text, where the user moves spatially around a map and accesses text information about nearby or intersecting objects (Biggs, Toth, et al.; Hennig et al.; Loeliger and Stockman; Zhao et al.; Biggs, Yusim, et al.).
- Audio description, which includes detailed text descriptions of the maps that often spans multiple pages with nested headings (Conway et al.; UniDescription).
- Chat interfaces where users provide open-ended queries to a chatbot to understand the information (Froehlich et al.; Jain et al.).

Despite these methods, most major map tools fail to provide any text alternative by default (Biggs, Coughlan, et al.). The text representation needs to allow the user to generate their own routes, perform spatial modeling to understand "What is nearby and why," make decisions based on multiple layers of information, understand what spatial relationships are not present in the data, and comprehend spatial information at a professional level (Arundel and Li). There are non-visual sensory map representations, such as raised-line tactile maps (Biggs, Pitcher-Cooper, et al.), 3D model maps (Coughlan et al.), vibro auditory maps (Giudice et al.), and auditory maps (Loeliger and Stockman), but WCAG requires a digital keyboard accessible text map.

The concept of equivalent purpose invokes the idea of an amodal representation (i.e., a sensory-agnostic representation). However, unlike the three amodal definitions (amodal relations, amodal mental categories, and amodal cognitive processes) presented by Spence and Di Stefano, WCAG invokes the need for a textual-linguistic amodal definition. Maps have traditionally been accessed through a single informational sensory modality - vision, audio, or touch - but WCAG calls for a cognitively mediated linguistic text representation. This is because text can be read in all three of the above informational senses, which is usable to a wider number of users (World Wide Web Consortium (W3C)). Text maps are less researched than sensory map representations, despite their greater universality (White).

There are hundreds of definitions of a “map,” most of which are vision-centric, but at a map’s most fundamental level, all these definitions agree that the purpose of a map is to communicate “generalized spatial information and relationships” (Lapaine et al.; *Map Definition*; *Map Definition*). “Generalized” means symbols are being used to approximately represent the real-world (e.g., as Belgian artist René Magritte asserted in “The Treachery of Images,” “Ceci n’est pas une pipe” (“This is not a pipe”) (Harvey)). Common symbols on maps include points, lines, and polygons (White). “Spatial information” is about where features are, and what they are like (e.g., shape, size, orientation, location, and other properties) (Li and Huang; Arundel and Li). “Spatial relationships” mean that location, distance, topological intersections and adjacencies, and direction between objects are core to understanding the information in the representation (Arundel and Li; Clementini et al.). Representation in this context is a digital depiction of data. This paper and definition focuses on two-dimensional geographic maps, but other spatial representations (e.g., mind maps, anatomical diagrams, and three-dimensional diagrams) may also fit this definition. This map definition is meant to be fundamental to every two-dimensional geographic map, no matter the subpurposes it may have (e.g., historical, navigational, or analytical). Since the fundamental purpose of a map is to communicate generalized spatial information and relationships, equivalency could be determined by assessing the quality and comprehensiveness of these three areas.

Information communicated via maps can be categorized under such labels as landmark, route, and survey knowledge (Siegel and White). Using the implicit variables provided by Siegel and White, and other cartographic elements, this paper proposes a set of measurable variables and an assessment that can be used to evaluate the communication of landmark, route, and survey knowledge (Biggs, Coughlan, et al.). Landmark knowledge includes the feature-specific cartographic variables of shape, size, orientation, and temporal information (Roth; White; Song), as well as feature name and type (Guidero), and the numeric and or categorical variables used in thematic maps (Foster). Survey knowledge includes distance, direction, topology, and location relationships of all features on a map (e.g. global configuration (Arundel and Li; Li and Huang; Clementini et al.)). Route information is not present on all maps, but it consists of how to get between two or more features on a map following a particular defined path, including the landmark and survey elements for the designated route object, and that the route information is as prevalent in the text map as it is on the visual map (Arundel and Li; Aziz et al.). With such an approach, these fundamental and measurable variables should be able to convey all generalized spatial information and relationships present in a map representation to determine equivalency (e.g., density using distance, size, topology, color, shading, and shape). The evaluation in this paper will use the equivalent purpose variables provided in these last two paragraphs to determine if different representations meet WCAG SC1.1.1 standards.

Table 1: landmark, route, and survey areas and definitions

Type	Spatial Knowledge Variable	Row Description	Example of Top Rows, and Passing Evaluation Area

Map Representation Description		Representation Description is a description of the representation being evaluated using this framework. The descriptions will all be in this row. This is not a description of the contents of the map, but a description of how the representation map being evaluated works.	A table has rows for all objects on the map, and a column for the numeric or categorical object properties.
Text Map		This is the text version of the map that is being evaluated against the visual map. It is important to keep in mind that the text map is being compared with the visual map, and not being evaluated on its own.	https://purvasingh96.github.io/accessible-maps/#/tables/table1
Visual Baseline Map		The Visual Map Comparison is a visual only map that the representation in the row above is being evaluated against. This is the baseline representation. It is the map as originally represented, via original file, screenshot, or image, if analog.	https://purvasingh96.github.io/accessible-maps/#/maps/map1
Total Purpose Items Passed:	0/3 Items Passed	The purpose of a map is to communicate generalized spatial information and relationships. These are the three components of a map at its most fundamental level. If any of these three elements are missing, as compared with a visual comparison, then the purpose of the map is not being met. You should add a fraction in this row, the top number is the passing elements, and the bottom number is the total elements. This is the first quick evaluation to identify if further evaluation is needed. Note: if the area is not present on the visual baseline map, it does not need to be evaluated on the text map.	2/3 Items Passed

	Generalized:	General means that "something" is being used to represent the real-world. The primitive map symbols are points, lines, and polygons. Are all the points, lines, and polygons for every object on the visual map, described in detail on the text map? All objects on the visual map should be present on the text map.	Johnson Hall is a rectangle two feet long and five feet high. It has a point indicating a door on its southwest corner, facing west.
	Spatial Information:	Spatial means that shape, size, and orientation are described in detail for each object present on the text map. Is the shape, size, and orientation described for each object on the text map?	Johnson Hall is 30 feet west (3 o'clock) from the Rec Center. They are both located on the Wonderful University campus, and the Rec Center is at the very northwest corner of the campus.
	Spatial Relationships:	Relationships are the connections between multiple objects. Is there a way to understand the distance, direction, topological, and relative location of every object on the text map between every other object on the text map? Is it possible to understand a line connecting each object on the text map?	Johnson Hall is 30 feet west (3 o'clock) from the Rec Center. They are both located on the Wonderful University campus.
Total Equivalent Items Passed:	0/15 Items Passed	This is a fraction summing all three spatial knowledge areas. the top number is the passing items, and the bottom number is the total number of applicable items. If there are items that are not applicable, they can be left out the total number of items on the bottom. Sum all landmark knowledge, route, knowledge, and survey knowledge areas. Note: if the information is not present on the visual baseline map, it does not need to be evaluated on the text map and should be marked N/A.	2/15 Items Passed

Landmark knowledge:	0/8 Items Passed	Landmark information is the individual characteristics of every object on the map. These areas should only evaluate the objects present on the text map against the visual baseline map. Go through each object on the text map and evaluate each landmark area against the same object on the visual map.	8/8 Items Passed
	Sensory characteristics:	These are the colors, sounds, visuals, smells, and other characteristics that are communicated with the user. An example would be a “blue” color being used to represent water on the visual map. This information needs to be described on the text map. The map key is where this information is often provided.	Water is represented through a corn blue color, grass is represented through a dark green color.
	Name:	This is the label of the object, or how the object is referenced when discussing the information on the map. For example, a road could be named: “Fillmore St.”. Every object in the text map needs to have a name of some kind.	Fillmore St.
	Type:	The type is a categorical descriptor for the object. For example: “Street”, “Walkway”, “Restaurant”, etc. This could also be derived from the name (e.g., “Fillmore St.” the “St.” means “Street”, which is the type).	Street

	Shape:	The shape consists of the detailed borders of an object. The borders of each object on the visual map need to match the borders or shapes described on the text map.	A simple description could be: “Rectangle”, but an irregular complex shape requires more description, for example: “Idaho’s northern border is relatively short, about 40 miles, confined to the narrow panhandle, and is defined by a straight line that separates it from British Columbia, Canada. The eastern border with Montana and Wyoming starts in the north with Montana. For around 100 miles with a 5:30 o'clock slope, the border is fairly strait going north to south with a very gentle slope east. A stronger eastern curve going from 5:30-3 o'clock into Montana happens, and Idaho eventually has Montana completely to the north for about 150 miles until it reaches Wyoming. The eastern border between Idaho and Wyoming is strait for around 100 miles. The southern border is strait for around 479 miles (its widest point). The southern border is split equally between Utah in the east and Nevada in the west. The eastern border between Oregon and Washington is strait for around 305 miles, and 60% in the south is the border with Oregon and the 40% in the north is with Washington.”
	Orientation:	The orientation can be combined with the shape description, but should consist of the border objects and how the object relates to those objects, and how the shape is facing. The orientation of every object on the visual map needs to be described on the text map.	“The Blue Tavern is a triangular building with the point of the triangle facing northwest at 11 o'clock. The point touches Fillmore St. To the northeast side of the building is Freedom Parks, to the south is Green Laundromat, and southeast, along the flat side of the triangle, is a patio for the bar.”
	Size:	The size are the particular dimensions of the perimeter of the object. The size that is shown for every object on the visual map needs to be described on the text map.	“Blue tavern has 3 walls. The two long walls that connect at a point are 50 meters long, and the short wall leading on to the patio is 20 meters long.”

	Temporal:	Temporal information is the change in data (geographic, numerical, or categorical) over time. If it is possible to observe data change over time on the visual map, then the same time change information needs to be described on the text map. If it is not possible to view different data from different times on the visual map, then write "N/A" in this section. You should be looking for timelines, line graphs, or settings to change the date.	The number of total COVID cases over the U.S. from 1/1/2021 to 4/1/2021: 1/1/2021: 500020 2/1/2021: 502000 3/1/2021: 512000 4/1/2021: 523110
	Overlaid information for thematic maps:	Overlaid information for thematic maps consist of the one or more numeric or categorical variables associated with each object. These are normally additional properties attached to each object on the map. This will be different categorical variables than "type", since type is its own item. The overlaid information is normally statistics (e.g., population data). If it is possible to observe different overlaid information on the visual map, then that same data needs to be described in the text map.	California: 543 Total Cases, 5 Total Deaths, and Yes masks Required.
Route:	0/3 Items Passed	Route information are the defined routes on the map. These are normally navigation routes from point A to point B following some kind of path. If there are defined routes present on the visual baseline map that are not present on the text map, all areas in this section fail. Compare the routes on the text map with the routes on the visual baseline map. If there are no defined routes, this entire section should be N/A.	N/A
	Landmark Information:	Make sure all applicable areas of the landmark knowledge section pass with the object representing the defined route. Take into consideration distance markers, shape, length/size,	There is a blue line tracing the shape of Fillmore St. Every 75 feet there is a blue marker showing the length. There is a blue marker 2/3rds of the way along the line. The line is strait going south to north and

		orientation, color, etc. If any items fail from the landmark section for any of the routes, write the entire section as a "No".	represents 94 meters. The line starts at 3321 Fillmore St. and ends at 1283 Fillmore St. The line angles from south to north at a 2 o'clock angle.
	Survey Information:	Make sure all applicable areas of survey knowledge are evaluated on each defined route in relationship with the other objects on the map. These other objects include intersections, intersection types, buildings, etc. If any items fail from the survey section for any of the routes, write the entire section as a "No".	The line starts at 3321 Fillmore St. and ends at 1283 Fillmore St. The line begins at the center of the 3321 Fillmore St. building, and continues 10 meters 3 meters in front of the building on the west side of Fillmore St. The route then crosses Clay St. for 4 meters with a stoplight intersection. On the northside of Clay and Fillmore the route continues for 5 meters in front of Dunkin Donuts, 10 meters along Lululemon, 20 meters along Wells Fargo bank, 10 meters in front of a parking lot, 5 meters past Boba and more, 20 40 meters in front of a Safeway, and 10 meters along the front of 1283 Fillmore St., ending half-way along 1283 Fillmore St.
	Prominence:	The defined route information should be easy to find and chunked in its own section. The time it takes to find the route information on the visual map should be around the same time it takes to find the information on the text map, although the text map will probably be a little slower because text takes time to read.	Routes: Route 1: 3321 Fillmore to 1283 Fillmore There is a blue line tracing the shape of Fillmore St. Every 75 feet there is a blue marker showing the length...
Survey:	0/5 Items Passed	Survey information is the overall understanding of how every object is related spatially to one another. If there are objects present on the visual baseline map that are not present on the text map, then all items in this section fail. Go through each object on the text map and evaluate if it communicates the same survey information as the same object on the visual baseline map.	Relative Location example: The Red room is a square in the center of the map. The bottom right corner of the square green room is 23 meters and 6 o'clock from the red room. The bottom right corner of the triangular Yellow Room is 10 meters and 2 o'clock from the red room, and the bottom edge of the yellow room is parallel with the top edge of the Red room. The top left corner of the rectangular Orange

			room is 5 meters and 4 o'clock from the Red room.
	Distance between all points, polygons, and lines:	Distance is how far each object is from another, typically using Euclidean distance. This is using the “as the crow flies” distance, not taking into account objects between the starting point and the ending point. If this distance information is present on the visual map, it needs to also be present in the text map.	The green room is 23 meters from the red room. The Yellow Room is 10 meters from the red room. The Orange room is 5 meters from the Red room.
	Direction between all points, polygons, and lines:	Direction is the angle between each object. For example: Fillmore St. is 85 degrees from Clay St., or using more imprecise methods if the map is not as complex (e.g., Sandwiches and More is 2 o'clock from Men’s Haircuts; or The Dry Cleaner’s is right of Shoes and More; or Pet Grooming is east of The Crabcake House). The important aspect is that the angle between each object shown on the visual map is accurately communicated in the text map.	The green room is 6 o'clock from the red room. The Yellow Room is 2 o'clock from the red room. The Orange room is 6 o'clock from the Red room.

	Absolute location of all points, polygons, and lines:	Are the exact coordinates for the object present? There are two types of location: absolute (with coordinates), and relative (how objects relate to each other). If the map provides access to absolute location, then that should be present at an equal level to the baseline map. Additionally, the relative location between every object needs to be provided through a combination of distance and direction in the other survey areas. If the baseline map shows graticules, the distance and direction between the different graticules and the edges of each shape should be provided. If coordinates are given through a number, then the same coordinates should be provided in both representations. If no absolute location information is present in the baseline map, indicate N/A. If the baseline map and the map being evaluated contain absolute information for the same objects, then write “Yes”, otherwise, write “No”.	Absolute location example: The right edge of the 5 meters h and 10 meters w rectangular Red Room is 10 meters west of the 9 degrees E graticule, and the bottom edge of the Red Room is 150 meters north of the 45 degrees N graticule. The center of the Red Room is at 45.0013722° N, 8.9998094° E.

Method

Eight text representations were evaluated against a visual map that was either next to the text map in the source document (e.g., the text directions evaluated were provided next to the visual map on the Google Maps website), or both the text map and visual map were created by the research team based on examples in the literature. Four of the maps were *taken* directly from an existing website, and four maps were created by the research team *based* on existing literature or real-world examples: (1) Turn-by-turn directions were taken from Google Maps since directions have been suggested as a text map alternative, and the corresponding visual map was taken from the same Google Map link (Sloan; *ClickAndGo Wayfinding*); (2) The table map was based on the table presented as a map alternative from *United States COVID-19 Cases, Deaths, and Laboratory Testing (NAATs) by State, Territory, and Jurisdiction*, as well as existing literature, and the visual map was also based on the CDC map (Sloan; Colorado OIT-GIS); (3) The Nearby Address Search example was taken from Bank of America Corporation. and also described in the literature and used by other major map tools, and the visual map was also taken from the same link as the text map (*mapbox-gl-accessibility*; Logan, *Accessible Maps on the Web*; Logan, *Let's Make Maps Widely Accessible*; Juan-Armero and Luján-Mora); (4) The Short Text Alternative was based on the practice outlined in McCall and Chagnon where the alternate text should be less than 140 characters, which has been reflected in alternate text guides across the web (Desrosiers), and the visual map was also a Google Map of the described location; (5) The Google Maps Interactive Alternate Text was taken from Google, and the visual map was also taken from the same Google Maps link; (6) The Audiom Map Interactive Alternate Text was taken from Biggs, Toth, et al. and *Welcome to XR Navigation!*, and the visual map was taken from the same link; (7) The Multy User Domain (MUD) Map Interactive Alternate Text, a map split into "rooms" that users move through by typing cardinal directions, was built using Griatch and based on text adventure maps or Multi-User Domain (MUD) maps (The Mud Connector; Williams; Biggs, Yusim, et al.), and the visual map was a map of the Pacific Northwest with COVID cases; (8) The Audio Description was written in a word processor and based on the guides presented in *UniDescription Academy* and existing map audio description literature (Conway et al.), and the visual map was the same map of the Pacific Northwest with COVID cases, mentioned above. Since Google Maps are present on 18% of websites, which is 11 times more than the second-most popular map tool (Leaflet (Agafonkin)), it was used more heavily than other tools in the evaluation (*BuiltWith Web Technology Usage Statistics*).

The MUD Map and Audio Description texts were written with the above MEP Framework in mind. The reason for keeping the framework in mind while writing the text was because it is otherwise easy to leave out details from the map text, but it is also easy to add those details in if they are missing. Many example descriptions were reviewed that follow the *UniDescription Academy* guidelines, but often there were small details missing (e.g., the shape of one object was not described, or size information was missing for a few objects). Since it was the technique being evaluated for this paper rather than an individual description, the research team created their own description, systematically considering all elements of the MEP Framework. The MUD Map and Audio Description text were the same, the difference between the two maps was in the text navigation method. MUD maps split text into "rooms" of varying size that are navigated to by typing cardinal directions (e.g., n, s, e, w) and each "room" has its own text description. Audio descriptions are long-form text indexed by headings and paragraphs rather than rooms.

Using the MEP Framework, eight textual map representations were independently evaluated against a visual map by three members of our research team. After the initial evaluation by one researcher, the definitions and evaluation were refined by the team, and two new researchers, with no prior knowledge of the topic, were brought in to independently evaluate the text representations using the MEP framework. They were provided with the visual map, non-visual map, the above template with definitions, and a guide on how to use the template. Once the two new researchers completed their first round of evaluations, intercoder reliability was 35% using the average Cohen's Kappa. The three researchers then met and discussed the definitions for each area, and refined the definitions of each area and for the text representations for a second evaluation round. After the second round of evaluations the intercoder reliability was 69%. The head researcher then went into each evaluation, and reviewed the areas that the reviewers were differing on and asked for clarification, to resolve contradictions, and for the reviewers to update sections that did not match the provided definitions at all. In the third round, intercoder reliability was 91%.

The evaluation consisted of the researcher reviewing first the non-visual map, followed by the visual map. Rather than evaluating each map directly against the criteria, the two maps were directly compared. This comparison is critical, because if the visual map lacked functionality, then the area would be considered N/A, instead of a fail. If there was no way to view coordinates on the visual map, but the text map did have coordinates, the answer would be "N/A". Although this is not required to effectively use the MEP Framework, a justification was provided for each pass or fail decision. If there was a partial pass, the ultimate score was a fail, but with a note of the partially passing element. Above each section is the sum of passing variables divided by the total number of variables in the section (e.g., 2/3 means 2 out of 3 purpose variables passed).

The three nominal purpose variables defining a map (generalized, spatial, and relationship, described above) were evaluated first. These variables required a conceptual evaluation of the representation. The equivalency variables were evaluated second, and had a total of 15 criteria, although one criterion (overlaid information) was only applicable to thematic maps. These criteria were a mixture of nominal, ratio, continuous, and circular variables.

The final template, the guide to use the template, and the final evaluation with majority agreed-on variables can be found at:

https://docs.google.com/spreadsheets/d/1led7iIbWMd_6RaMkZYqd27zelX1H18YIlqYR40OkSis/edit?gid=83976719#gid=83976719

Results

Figure 1: Bar Chart Showing Scores

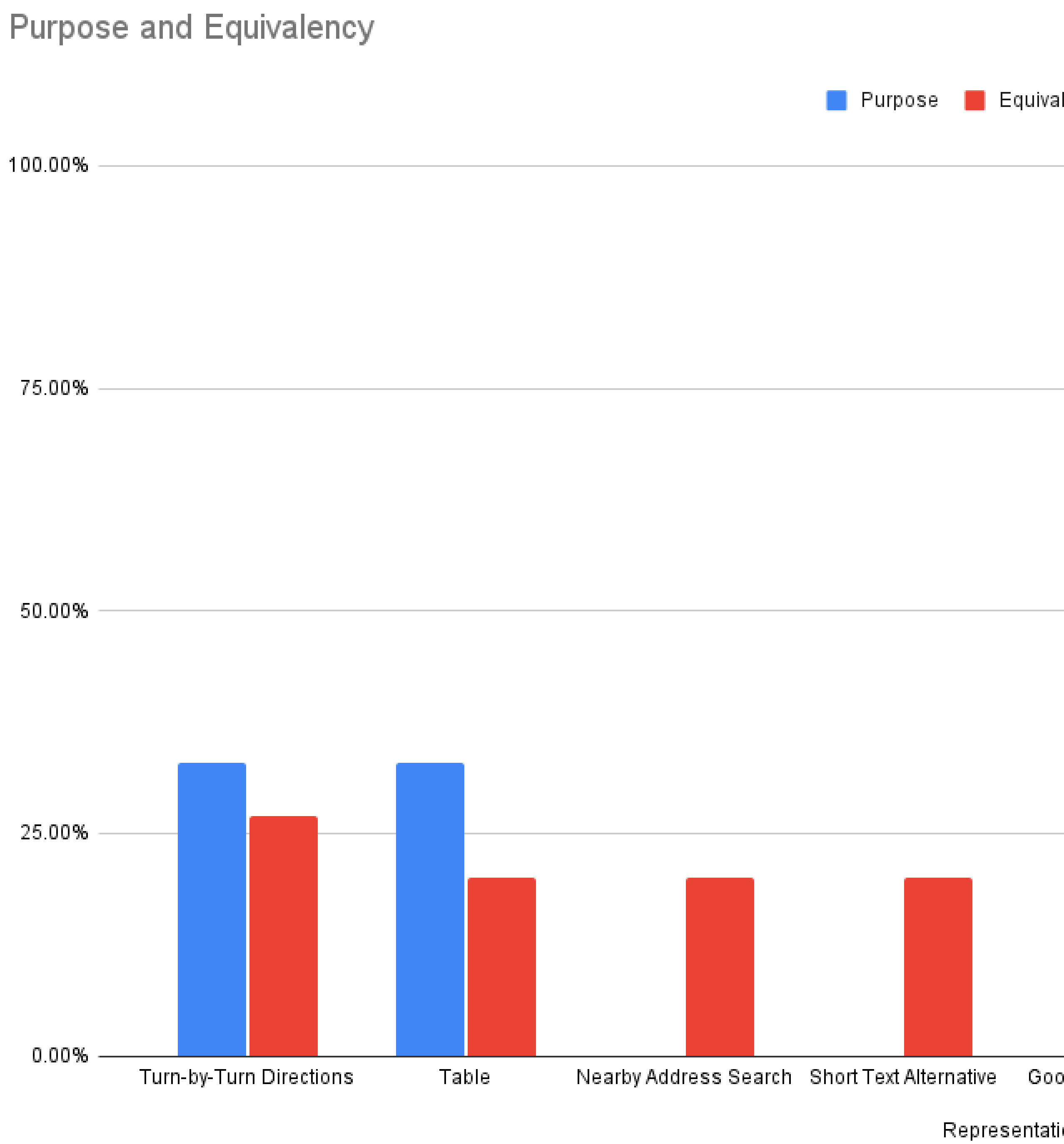

Table 2: Table Showing Scores

Text Map	Purpose	Equivalency
Turn-by-Turn Directions	33.00%	27.00%
Table	33.00%	20.00%
Nearby Address Search	0.00%	20.00%
Short Text Alternative	0.00%	20.00%
Google Maps Alt Text	0.00%	30.00%
Audiom Map Alt Text	100.00%	100.00%
MUD Map Alt Text	100.00%	100.00%
Audio Description	100.00%	100.00%

Out of eight map representations, three (Audiom Map Interactive Alternate Text, MUD Map Interactive Alternate Text, and Audio Description) passed the MEP Framework evaluation and showed they served the equivalent purpose to their corresponding visual map. When representations failed, a maximum of one out of three items passed the purpose test, and three out of fifteen items passed the equivalency test. Moreover, if a representation failed the purpose test, it consequently failed the equivalency test. The difference between passing and failing representations was substantial in the equivalency test: passing maps achieved 100%

equivalency, whereas failing maps averaged 23%, producing an approximate 77-point performance gap.

The largest discrepancies were observed in spatial information and survey knowledge-variables that depend on communicating shape, size, orientation, distance, and direction between features. Missing objects in the text maps were the primary cause of failure; four of the five failing maps lacked the same number of features as the visual map. When features were missing from a text map, all areas of survey knowledge automatically failed, since the core requirement for evaluating survey knowledge involved assessing relationships among all points, polygons, and lines on the map.

Landmark knowledge showed the smallest gap across representations (an average of 39% for failing maps versus 100% for passing maps). Most representations successfully conveyed object names and types, although sensory and size information were often missing. Route knowledge was not applicable in most cases, but the one text map with defined routes (Turn-by-Turn Directions) omitted all features outside the route, as well as the alternative routes presented on the visual map. Survey knowledge could not be evaluated for any of the failing maps due to missing features.

Discussion

The results show that many legacy text map methods (e.g., tables and turn-by-turn directions) fail the MEP Framework evaluation and are not WCAG compliant. The biggest failures were the text map missing features, and failing to communicate the spatial relationships between features. Several other passing text alternatives are provided, although it is critical that a holistic, and systematic, map creation approach be performed to ensure equivalent purpose to a visual map. The “primary purpose” or “point” of a map is important as a piece of the textual information, but is insufficient on its own. There could be use cases for a map that are outside the imagination of the describer but are possible using the visual map, and these cases need to be accounted for in the description as well to establish equivalence of information. For example, originally, the graphic for the audio description and MUD Map contained the names of small cities, but these were not provided in the text description. In this case, the visual map was updated to remove the city names to match the text description.

Aside from everyday uses, having equally accessible maps is critical for BLVIs to participate in map-dependent professions. Although the number of BLVIs in map-dependent professions is generally unknown, fewer than a fifth of BLVIs even have used a tactile map (Bleau et al.), and those who have used a map report using fewer than one per year, on average (Biggs, Pitcher-Cooper, et al.). This is in contrast to sighted users, who view more than 300 maps a year on average (Savino et al.). Besides common uses, numerous lucrative professions also require the use of maps (Department of Geography and Geosciences, Salisbury University), and the widespread lack of comprehensive map text descriptions is keeping people from these jobs just because they are BLVIs. Map tool creators, such as those evaluated in the paper by Biggs and colleagues Biggs, Coughlan, et al., need to use one of the passing methods to be considered compliant with the new global accessibility legislation and create equality in the cartographic-dependent professions. Government agencies need to evaluate map solutions using the MEP Framework, along with the other WCAG criteria outlined in Biggs, Coughlan, et al., to ensure BLVIs and other disabled people are able to participate in civic projects, access emergency information, understand utility maps, and work in professions depending on these maps. State and local government documentation needs to be updated based on the results of this evaluation

(Colorado OIT-GIS; Minnesota IT Services). Both the European Accessibility Act and The Public Sector Bodies Accessibility Regulation should also remove the explicit exception for thematic maps, since all three passing maps in this evaluation were thematic (European Commission; *The Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018*).

Conclusions

The goal of this paper was to develop a systematic evaluation framework, the MEP Framework, for assessing the equivalent purpose between text-based and visual geographic maps, as required by WCAG 1.1.1. Eight text-based map formats were analyzed using the MEP Framework. Based on the framework's criteria, only three formats (interactive Audiom maps, MUD maps, and audio descriptions) satisfied the requirements for equivalent purpose. In contrast, tables, turn-by-turn directions, nearby-address search tools, Google Maps interactive alternative text, and short alternative text did not meet the framework's criteria. These findings indicate that such formats should no longer be considered sufficient for meeting WCAG 1.1.1 compliance.

Although the MEP Framework has been applied through expert analysis, further empirical validation is required. Future research should include controlled experiments in which participants complete spatial-knowledge tasks under multiple map conditions (e.g., visual maps, tables, and interactive Audiom maps). Such studies are necessary to determine whether the framework reliably predicts equivalent purpose in practice and to test the emerging Equivalent Purpose Theory of text Map Accessibility, which posits that a text map achieves equivalent purpose when it supports the same generalized purpose, spatial information, and spatial-relationship understanding as its visual counterpart. The spatial-knowledge components defined in this work can be used to generate detailed tasks and assessment items for evaluating the effectiveness of different map representations.

It is important to note that asking BLVIs about what they want to know about a map is helpful for identifying what information to highlight, but it is not a thorough and valid technique for determining what information should be included in a non-visual map. Few BLVIs have used maps before, so their fundamental understanding of the potential and possibilities of a map is generally lacking. This approach is similar to asking monastic scribes, who only have access to quill and parchment, what features they want in their word processing software (Bleau et al.; Biggs, Pitcher-Cooper, et al.).

Another limitation is the lack of temporal representations in the dataset. Additionally, interpretive maps, such as those created from large vision models, were not evaluated (Froehlich et al.; Jain et al.). Future research should also investigate map creation tools and how the MEP Framework can be extended to drawing and creating maps (Clepper et al.). Although the MEP Framework is specific to maps, there is no reason why other types of spatial diagrams (e.g., biological, mind maps, architectural) would require additional spatial-knowledge variables.

Further, while the MEP Framework used a visual map as a baseline, future work should investigate whether other non-text maps (e.g., tactile or multisensory) function just as well. If these perceptually-based sensory representations demonstrate that they communicate an equivalent purpose to the visual map and there are options for users unable to use one or more senses, they may become WCAG-acceptable for SC1.1.1. Future work also needs to investigate creating evaluation frameworks for other types of digital data representations to evaluate the equivalent purpose (e.g., bar charts, 3-dimensional objects, candlestick charts, Sankey diagrams).

The proposed MEP Framework provides a common evaluation template for all geographic text maps, regardless of their purpose, and the evaluation suggests traditional text maps (e.g., tables) are insufficient to meet WCAG. The MEP Framework can be used both for comprehensively developing new text map representations and for evaluating existing methods for WCAG conformance. Conversations around digital map accessibility can explicitly name all the elements that "screen reader accessibility" consists of. Benchmarking assertions for large vision models can also be created using this framework. The framework clarifies the ambiguity surrounding "equivalent purpose" for maps, expands W3C technique G92, demonstrates that legacy text map methods are inadequate, and provides text map examples that should facilitate the employment of BLVIs in cartographic professions.

Supplemental Data

A Google Sheet with the template and coded data can be found at:

https://docs.google.com/spreadsheets/d/1led7iIbWMd_6RaMkZYqd27zelX1H18YIlqYR40OkSis/edit?gid=1478717446#gid=1478717446
https://docs.google.com/spreadsheets/d/1led7iIbWMd_6RaMkZYqd27zelX1H18YIlqYR40OkSis/edit?gid=1478717446

A permanent archive of the above template can be found at:

Biggs, Brandon. Systematically Evaluating Equivalent Purpose for Digital Maps - Data. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2025-11-03. https://doi.org/10.3886/E239621V1

Disclosure of Interest

Mr. Biggs is the founder and CEO of XR Navigation (https://xrnavigation.io). Dr. Brett Oppegaard is the founder of AccessHound (https://accesshound.com). Dr. Nicholas A. Giudice is a founder of UNAR Labs (https://www.unarlabs.com/). All three companies work to make digital maps accessible.

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