What is Mobile First Cartographic Design?

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ABSTRACT
In this position paper, I outline a set of open questions facing *mobile first* cartographic design. My opinions are preliminary and partial, and serve as a starting point for considering new design strategies for mobile map UX.

Author Keywords
mobile cartography, user experience design, mobile first

TOWARDS MOBILE FIRST CARTOGRAPHIC DESIGN

Today, more maps are viewed on mobile devices than in any other format, media, or platform. Yet, much of the cartographic canon we teach and practice was established for the design of printed maps, where ink is immutable but precise, map sheets are big but foldable or bound in an atlas volume, and map design bends to the mapmakers' intentions rather than the map users' individual needs and context. Even contemporary treatments explicitly on interactive and web-based cartography rarely consider mobile as the primary design platform [see 1 for one notable counterexample], instead imagining widescreens, external input devices, and reliable networks and bandwidth. ***How must cartographic design adapt to consider mobile first?***

Mobile first describes an approach to user experience (UX) design optimized for the technological constraints of mobile devices, such as smartphones, tablets, and heads-up displays. Constraints include: small screen viewing, reduced processing power and memory capacity, unreliable connectivity and reduced bandwidth, limited battery life, and multitouch post-WIMP interaction [2]. However, these constraints give mobile devices their fundamental utility: the physical mobility of the device in the landscape. Mobile first therefore is a design philosophy that considers the most *constrained* user experience before others and then adapts design to more flexible use cases [3].

The topic of mobile first design was proposed for discussion at the 2015 ICA joint commission workshop in Curitiba, Brazil [4]. While several of the resulting research agendas tangentially approach mobile first cartographic design [5-9], none systematically treat its implications for cartographic design. This position paper builds upon these reviews to consider open research questions facing mobile first cartographic design. Organization of research questions is based loosely on the recent ICA Use Commission review of mobile mapping provided in [10].

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NEED: MOBILE FIRST MAP PROJECTIONS

Recommendations in the literature for mobile first map projections include centering the map on the user's location, updating the user's position while moving, and rotating and tilting the map so that forward is up, design considerations described as an *egocentric* viewpoint [11].

- *How do egocentric projections on mobile maps impact spatial knowledge acquisition?* Egocentric views have been critiqued by cartographers for shifting emphasis from configural to procedural knowledge, ultimately impeding spatial cognition [see 5 for a review]. While the utility of egocentrism likely depends on the use context, it increasingly is an expected default, resulting in a tension in mobile map UX design.
- *What focus+context visualization techniques are useful for mobile first cartographic design?* A number of projection and distortion techniques have been developed in information visualization to provide both overview and detail information, solutions described as focus+context visualization. Focus+context techniques may be useful alternatives to egocentrism in mobile first cartography [12], but are rare in mobile maps.
- *How should egocentric projections respond to non-mobile devices*? An egocentric projection primarily makes sense when moving. While egocentrism has niche applications in visual storytelling and thematic mapping, such perspective projections inhibit many map reading tasks and use cases. This is a growing concern as "Tilt-Shift" functionality has become common in web mapping packages, leading to a recent spike in web maps with default oblique projections.

NEED: MOBILE FIRST SCALE & MAP GENERALIZATION

Recommendations on the default scale and level of generalization for mobile cartographic design is varied in both research and practice [13-16], with detailed maps and imagery offering greater clues for landmark association but simplified maps better accounting for mobile limitations on screen size, bandwidth, and data plan. Specifically:

- *How do we generalize mobile maps at a human scale?* While maps as mental abstractions are unbounded by scale [17], most cartographic generalization principles are developed to treat phenomena at a scale larger than a human body but smaller than our world. Larger map scales usually mean more detail, but why retain all detail at the scale of the human when we already can observe our environment in all its complexity through our senses? We need to rethink principles of selection, simplification, etc., to support meaningful abstraction at the human scale.

- *What level of detail is appropriate for mobile augmented reality?* Augmented displays use mobile first cartographic design not to abstract reality, but instead to overlay otherwise unseen information onto reality [18]. Mobile AR represents a fundamental shift in the relationship between maps and generalization: rather than generalizing a map to cull meaning from the complexity of the real world, augmented displays overlay generalized layers atop this complexity to provide *more* detail than is observable directly. What additional details should be provided and why?
- *How do we consistently generalize mobile maps for both indoor and outdoor navigation?* Designing egocentric displays at a human scale requires mobile maps that work seamlessly between indoor and outdoor environments. Indoor-outdoor mobile cartography raises a number of questions about data and design, including geographic vs. spatial data harmonization, multi-floor navigation and symbolization, connectivity lags, and public safety [9].
- *Should cartographic generalization be speed- rather than scale-dependent for mobile first cartography?* Topfer's law [19] suggests that information complexity is determined by cartographic scale, but is this true for a map that might be moving at variable speeds? Arguably, a mobile map (and users of these maps) traveling at higher speeds (e.g., driving vs. walking) need more overview and less detail, as they can access a greater region within a given amount of time. Thus, the size of the travel possibility space may be a better proxy for generalization than cartographic scale.

NEED: MOBILE FIRST MAP SYMBOLIZATION

Recommendations for mobile first map symbolization generally agree that increased brightness and contrast are needed within the visual hierarchy to account for variable environmental conditions [2, 14], with discussion primarily about reference rather than thematic symbolization.

- *How can we improve design of hamburger cartography?* Many mobile maps draw on tiling technology to present a user experience of "the map of everywhere". While tools exist to style custom tiles, designing a map at multiple scales with a global extent is a difficult and time-consuming task. Accordingly, many mobile maps overlay data layers atop a generic basemap tileset, resulting in so-called "hamburger cartography" [20]. Hamburger cartography requires us to rethink principles of symbolization, typography, and visual hierarchy to improve mobile first design.
- *What is mobile first thematic map design?* The cartographic canon prescribes a variety of thematic map design decisions based on the mapping context (data, audience, medium, etc.). Context is a continuum in mobile first and responsive cartographic design, breaking many of these prescriptions. We need to determine which thematic map design decisions are fixed to the data (resulting in an *intelligent* cartography), the user (resulting in an *interactive* cartography), and the medium (resulting in a *mobile first* cartography). One can imagine new design recommendations for class breaks, color schemes, scaling ratios—even the recommended thematic map type altogether—for the mobile medium.
- *How can multimodal, non-intrusive, and non-visual symbolization be used in mobile maps?* The nature of a moving device means that user attention often is split on other activities. There is a growing body of research on the design of multimodal, non-intrusive interfaces (e.g., voice input, haptic feedback) for submitting requests to the mobile map [see 9 for an overview], but there is far less attention on how to use non-visual methods for communicating information back to users, either interaction feedback or map information.

NEED: MOBILE FIRST MAP INTERFACES

Finally, mobile first cartographic interaction is natively touch-based and post-WIMP. A number of multitouch, direct manipulation map interfaces are now conventional, such as single tap to retrieve map details, double tap or pinch to zoom, grab-and-drag to pan, and two-finger twist to rotate [1], with other direct manipulation or widget-based solutions employed inconsistently for mobile maps.

- *What is the efficacy of emerging UI solutions for mobile interaction operators?* Many cross-platform responsive design frameworks now include a bevy of touch-based interface widgets that can be applied to mobile maps, such as hamburger menu buttons (used differently than the hamburger cartography introduced above), bottom navigation tabs, floating action buttons, and pull-up menus. Are some mobile UI solutions more or less suited for specific cartographic interaction operators and how should these mobile first UI solutions respond to non-mobile devices?
- *What mobile map interactions can be performed by physical or avatar movements, rather than requiring additional UI on the map?* Much like in a video-game, the body can be symbolized as an avatar on the map, with physical movement then "interacting" with the map through the avatar [21]. Avatar-based interactions make sense for operators like pan and rotate, but may be applicable for other operators as well.
- *How do we design inclusive mobile first cartographic experiences?* Designing at the margins makes all use cases more robust [22]. The multimodal, non-intrusive, and non-visual alternatives discussed above are one such example. Inclusive design is particularly important in mobile first cartographic design, as a user may be temporarily incapacitated while moving through variable environments [23]. Because mobile first means designing for the most *constrained* user experience before others, an inclusive mobile cartography requires grappling with unresolved issues of accessibility, disability, literacy, and other individual user differences in cartographic design [see 5].

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