Demonstration of a universally accessible audio-haptic transit map built on a digital pen-based platform

ABSTRACT
In this demo, conference attendees will try out a new system for providing multi-sensory transit and way-finding information about New York City subways to riders who are blind, visually impaired, or otherwise print disabled. The system includes a booklet of raised-line and textured maps of train routes; users explore the maps through various combinations of vision and tactile sense, and then touch the tip of a special pen to locations on the map to hear station names and other information spoken aloud. Train lines are rendered as narrow channels that help to guide a user’s hand as he or she moves the pen along a route, and small depressions within these channels mark individual station stops. This novel combination of tactile graphics and a haptic audio probe may provide an intuitive and information-rich interface that could help disabled individuals travel around the city with greater self-confidence, safety, and independence.

Author Keywords
Tactile, cartography, pen, computer, blind, subway, map, orientation

ACM Classification Keywords
H.5.2 User Interfaces (Haptic I/O, Audio (non-speech) feedback)

INTRODUCTION
Visually impaired travelers have difficulty accessing information that their sighted counterparts take for granted. For example, subway maps provide sighted riders with an overview of an entire network of underground trains, and also offer details about individual routes and stations. Without maps and other tools for acquiring up-to-date information prior to setting out on a journey, and for consultation en route, blind and low vision individuals experience navigation difficulties. This project embodies ideas that might help to reduce levels of inconvenience, frustration and hazard that often interfere with capable individuals’ efforts to reach their employment and education objectives. The authors have developed a practical system for making and distributing accessible transit maps that are portable and inexpensive to manufacture. This work combines static tactile images with dynamic audio content, and adds a proprioceptive component that may make the system easy and intuitive to use for transit riders with a wide range of capabilities and preferences.

Background
The New York City subway is one of the most extensive public transportation systems in the world, with 468 stations and 842 miles (1355 km) of track [1]. Understanding the layout of the system and planning routes between stations is a daunting exercise for many riders, with and without disabilities. The Map, originally developed in 1979, and continually updated since then, is appreciated by many transit riders, because it presents the system’s complexity in a surprisingly comprehensible way [2]. The map thoughtfully balances diagrammatic clarity and spatial accuracy [3], and it is the outcome of an evolutionary design process over more than 100 years. Without easy access to The Map, which is ubiquitously displayed in train cars and stations, and widely distributed to the public at no charge, navigating complex routes would be unmanageable for many riders. Yet, this is the exact situation faced on a daily basis by those who cannot see well enough to make sense of The Map in its current print-only format.

Project Description
The pen-enabled talking tactile subway map that is the subject of this demonstration appears to be the first portable and comprehensive cartographic system that is accessible to riders who cannot read print documents. In the current implementation, only the 1-2-3 lines are shown; in future versions, the entire system will be presented in a bound booklet of maps. Each page will show a single route, along with a simplified outline of the geographical context of the
four boroughs\textsuperscript{1}, and major parks and airports. While the map can be used by itself (two-character Braille abbreviations identify the most important transfer points and a legend for each subway line explains their meanings), its full potential as a navigational tool is only revealed when the map is used in conjunction with the computer-pen (Livescribe’s Pulse Pen [3]). This powerful, compact device, developed as a consumer product and used mainly as part of a smart note-taking system, includes a tiny video camera in its tip (see figure 2). The camera “sees” a very fine (almost invisible) Anoto dot pattern on the map’s surface, and through analysis of the position of the dots, the pen’s on-board microprocessor is able to determine the precise location of the nib on the map’s surface [4]. After consulting a program that associates each x,y coordinate position on the map with place names, the pen’s audio system plays recorded messages that include names of the stations touched. Additional useful information is embedded as a series of layers that are accessed when the user taps multiple times on a station. These layers include descriptions of platform and stations physical layout; information on transferring to connecting services, such as bus and ferry; data on routes and schedules; and instructions about what to do in case of an emergency. In Phase 1, this material will be collected for all 84 stations along the 1-2-3 line, output through a speech synthesizer, and saved to the pen’s 1 GB flash memory for playback on demand during map exploration.

CONCLUSION
This demonstration will introduce conference attendees to an innovative application of interactive audio-haptics. The New York City subway map system discussed here is an example of universal design, because it sets out to be usable by a very broad audience, it presents information in multiple and redundant formats, and it adapts to, or can be reconfigured for, a large variety of user profiles. If upcoming trials reveal that the subway maps are effective for blind and low vision transit riders, we envision other applications that leverage this technology, including DAISY-compliant illustrated digital talking books in categories such as children’s literature; technical manuals; tourist data; emergency preparedness information; standardized assessments; maps of all kinds; and text books and curricula for mathematics, history and the sciences.

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REFERENCES

\textsuperscript{1} Staten Island, the fifth borough, has its own separate above ground light rail system.