# Title: The Journey of the Monarch: Why Partnerships, Innovation, and a New Braille Standard Were Essential to Creating a Dynamic Tactile Display

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## Key Objectives:

* This paper will inform the reader of how decisions were made to design the Monarch’s tactile display to the chosen specifications, despite the project beginning just before Covid lockdowns occurred.
* The reader will learn about the partnerships that have been essential to ensuring that the creation of a dynamic tactile display was successful.
* Readers will be provided with a summary of the functionality of the Monarch.
* Readers will learn how the new eBraille standard directly enhances the power of such a dynamic tool, and why the success of this new standard has been as important as the Monarch itself.

Over the past 30 years, numerous companies have claimed to pioneer a breakthrough in dynamic tactile displays, each envisioning a device capable of seamlessly presenting both standard braille and tactile graphics on the same surface. bbbFondly dubbed the "Holy Braille" by the blindness community, this concept has long been a dream for braille readers.

Currently, braille readers rely on either traditional hard copy braille or single-line braille displays. The former offers the advantages of displaying multiple lines, spatial formatting, and tactile graphics, but can be bulky and time-consuming to produce. Single-line displays, while providing instant access to digital braille content, limit users to one line at a time and impede reading speed as the display requires constant panning every 40 or so characters.

The Monarch tactile display, a joint effort among the American Printing House for the Blind (APH), HumanWare, and the National Federation of the Blind (NFB), was designed to be a standalone device capable of displaying both tactile graphics and standard braille on the same surface. Recognizing the enormity of the task, the group engaged in numerous partnerships throughout the device's creation to ensure optimal use of braille in a multi-line digital context, with continuous input from blind users shaping every design decision. These partnerships resulted in several teacher training programs, user testing sessions, and the imminent completion of a new electronic braille standard (eBraille).

Starting in 2020, the goal of the project was to bring tactile textbooks to students in a digital format. In order to accomplish this, a new braille technology was needed that could enable the use of equidistant pins to create tactile graphics and standard braille on the same surface. APH and HumanWare partnered with DOT Inc, an innovative startup company out of South Korea, to utilize their new braille technology as the tactile display for the Monarch. Using a new braille cell design, DOT created the thinnest and most compact braille cells in the industry. The braille cells could now be placed in an equidistant array and combined with the Monarch’s computing power and software suite. Thanks to these innovations, the Holy Braille dream has been taking shape over the past four years.

Consisting of a tactile display capable of displaying ten lines of 32 braille characters as well as tactile graphics on the same surface, the Monarch’s hardware can display content found in a tactile textbook, but the uses in the classroom extended far beyond simply displaying a book on the display. Students wanted to both create and consume content on this tool and ultimately utilize it throughout their school day. This resulted in the development of productivity apps for the device, along with a design providing an ergonomic reading and writing experience.

The Monarch device is nearly the same dimensions as a 15-inch gaming laptop. Weighing around 4.5 lbs. (2 KG), the device is light enough to be with the student all day and fits in standard laptop bags. With an imbedded 8 dot braille keyboard, a student can create documents in either the braille editor or full Microsoft Word style word processor. They can include math expressions using their preferred math braille code and utilize the Monarch’s tactile graphing calculator powered by Desmos, to perform mathematical calculations. With an included HDMI port, anything touched on the tactile display can be shown visually for sighted teachers and classmates on a monitor or television.

One of the most challenging problems that needed to be solved was how to allow a user to place their cursor when editing documents if there were no cursor router keys. Because the Monarch’s tactile display is also touch sensitive, a new mechanism called “Point and Click” was developed to activate items on the display. The user simply points to an item on the display and double clicks the action button on the device to move the cursor or focus to that item. As an example, if a user wants to edit a word in a file, they simply touch inside that word and double click the Monarch’s action button to move the cursor to that location. Offering a touch sensitive tactile display has many other benefits that are utilized in other apps, such as pointing to where one wants to zoom in on a graphic and zooming in on that graphic in exactly that location. The device also offers more traditional key-based methods so that all users can quickly and easily place the cursor.

APH included access to its online Tactile Graphics Image Library (TGIL), a free library of thousands of tactile graphics, on the Monarch. When the Monarch is connected to WIFI, users can browse, view, and download graphics covering a range of topics from geography to STEM subjects. For the first time in history, students have instant access to on-demand tactile graphics that are completely searchable.

Why will the Monarch be different from other attempts at achieving this holy braille dream? Early on in the project we recognized that APH could not do this alone. It took a community of partners to make this dream a reality. The project needed expertise in manufacturing at a large scale, along with an innovation to braille technology. HumanWare and DOT brought this expertise. A decision also had to be made early on to determine if the initial tactile graphics focus would be on graphics created by tactile artists or print graphics that one could download from Google or other locations. Because of the textbook use cases and the availability of tactile graphics produced by tactile artists, the early decision to focus on existing tactile graphics and those found in textbooks has yielded great dividends. The goal of being able to download any visual graphic and filter it into a tactile form that can be interpreted by a blind user remains, but this is technology that has not been optimized yet.

It was an intentional goal at the outset that blind people needed to be at the core of every design decision. The partnership with NFB allowed us to implement this as part of the process at the very beginning, and blind users have been testing the device at every stage.

Lastly, in order to accommodate the next generation of digital braille files, it was clear that a new digital braille standard needed to be implemented. APH partnered with the DAISY Consortium and over 40 international organizations around the world to develop the eBraille specification. Keeping the integrity of braille formatting at the forefront, eBraille has been designed to bring all the benefits of markup found in DAISY or EPUB books to braille. With an eBraille book on the Monarch, a student could immediately go to page 57 of their textbook or notice that there is a graphic on a specific page. They could point and click on that graphic indicator and the tactile graphic opens in the Monarch’s graphic viewer app in real-time.

Set to launch in late 2024, the features of the Monarch listed here barely scratch the surface of what is possible when students have easy access to a touch enabled multi-line tactile display. This group’s belief is that such a tool will greatly help to improve literacy rates for students who are blind or have low vision, as well as increase interest in braille. APH tested with 42 teachers of the visually impaired and over 50 students in the U.S. and saw immediate engagement benefits. With the technology that is now available to developers, the gamified learning possibilities are endless. The next frontier in electronic braille is here and confidence is high that multi-line tactile displays are here to stay. The braille metamorphosis has begun!