Taking Touch Screen Interfaces Into A New Dimension
EXECUTIVE SUMMARY

SITUATION: **Touchscreen & Display-Based Technologies Lack Realistic Tactile Feedback**

Touchscreens have greatly improved the way users interact with devices, making them more intuitive and easier to use, but they come with a price. The absence of tactile feedback creates a host of problems, which negatively impacts user experience on a variety of levels. Device manufacturers are trying to address this issue through a wide range of solutions that attempt to simulate a physical button experience. Vibration-based haptics for instance, uses vibratory feedback to mimic the feeling of resistance when a virtual button is pushed. This approach cannot, however, recreate the true tactile response of an actual button press – a fact not lost on device makers such as Samsung®, Nokia®, RIM® and others that continue to develop physical keyboards for their products (even at the expense of user preference for more screen real estate and thinner devices).

Current haptic technologies also fall short in assisting users in properly locating their fingers on the screen or keyboard, because of the inherently flat nature of touchscreens. Without proper orientation, mistakes will be high. Given how fast touchscreens are being integrated into handheld devices such as digital cameras, gaming systems and smart phones to larger systems such as cars, medical devices, ATM’s and home controls, it is vital to have a tactile solution that helps users interact with them much more naturally, comfortably and safely, as is the case in automotive applications.

PROBLEM: **Lack Of Compelling Human Interaction Severely Compromises User Experience**

Data entry errors, poor typing speeds and the inability to even know if an input has been made are just some of the problems that plague users using touchscreen keyboards and touch input devices today. Interacting with a touchscreen requires constant visual monitoring; a person needs to take their attention off whatever they are doing to focus on the input interface. Merely inconvenient in situations like playing games, this can be actually dangerous in an automotive environment where touchscreens are used for tasks such as changing the radio station or interacting with the navigation system. The lack of physical buttons that prevents a person from feeling where they are also makes it impossible for the user to blind navigate (enter data without looking at the screen) or touch type.

Arm and finger fatigue is a common occurrence due to constant hovering, and even a slight adjustment requires a user to look at the screen to reposition their fingers. More importantly, entire segments of the population who can’t operate touchscreens are left behind. The blind and visually impaired, the elderly, those lacking fine motor skills because of diseases like arthritis or Parkinson’s either struggle or find themselves completely unable to use ‘buttonless’ touchscreen based devices.
**EXECUTIVE SUMMARY**

**SOLUTION:** The Tactus Tactile Surface, A Deformable Physical Layer That Provides Users With Tactile Feedback

Tactus Technology, Inc. has developed a patented solution to address all these issues.

The Tactus Tactile Layer™ panel provides a next-generation user interface with real physical buttons, guidelines, or shapes that rise out of the surface of a touchscreen on demand. The Tactile Layer component is a completely flat, transparent, dynamic layer that sits on top of the touch sensor and display. When triggered, this thin layer deforms and buttons or shapes of a specific height, size and firmness appear on the surface. Users can feel, press down and use these physical buttons just like they would use keys on a keyboard. When they are no longer needed, the buttons recede into the surface and become invisible.

The Tactus panel is the world’s first deformable tactile surface that creates dynamic, stable, physical buttons that users can actually see and feel, in advance of entering data into the device. Covered by more than 22 granted or pending patents, it uses innovative microfluidic technology to create physical buttons that rise and recede to give users the experience of interacting with physical buttons. It allows different pre-configured button arrays such as a QWERTY keyboard, to be raised or lowered. Not just limited to keyboards and on-screen buttons, the tactile technology can also be integrated off-screen, such as on the backside of a device or on a car door panel.

**RESULT:** A Truly Tactile Surface That Enables New Applications And Devices

The Tactus Tactile Layer component provides Original Equipment Manufacturers (OEMs), Original Device Manufacturers (ODMs) and display companies with the ability to make touchscreen devices that offer true tactile feedback to the end user. Not only can users or the software control when buttons appear and disappear, but the technology also enables them to rest their fingers on the buttons and enter data by actually depressing a real button.

Physical buttons have the potential to increase typing speeds, reduce data entry errors and make touch-typing and blind navigation on a touchscreen possible for the first time. It allows for the screen and keyboard to be combined into a smaller form-factor. Not having to reserve a separate space for buttons or keys also enables manufacturers to increase the size of their LCD displays and create entirely new forms of devices.
Ever since the Apple® iPhone® and iPad® arrived on the scene, the growth of touchscreen technologies has been nothing short of explosive. According to IHS® iSuppli™ Market Intelligence, a leading information and analytics provider, the popularity of these two devices have helped in tripling the size of the touchscreen market.

Manufacturers in many diverse industries are jumping onto the bandwagon to embed touch-enabled user interfaces in their products. More touch-centric displays can now be found in flat panel TV’s, computers, digital cameras, handheld video game players and portable media players – and the list continues to grow. A few key statistics from the IHS iSuppli Display Electronics topical report:

- Shipments of touch controller ICs are set to reach 2.4 billion units in 2015, up from 865 million in 2010. In 2012 alone, shipments will surge 28 percent to 1.7 billion units, with strong double-digit growth projected for the next two years before the rate of expansion slows slightly in 2015.
- Together, the number of devices and appliances using some form of touch controller IC is predicted to hit 1.06 billion units in 2012, nearly double from 514.9 million units only two years ago.
- Shipments of touch controller ICs exceed those of touch-screen-equipped mobile devices due to the use of more than one IC in each product especially in tablets, and also because of the relatively low manufacturing yield frequently seen in advanced touchscreen modules.

Gartner® analysts predict that more than 50% of personal computers purchased for users under the age of 15 will have touchscreens by 2015, with education being one of the leading markets.

Gartner expects touchscreen penetration to be evolutionary, influenced by factors such as price drops in touch-enabled hardware, the advent of sophisticated software and ergonomic improvements. Retail, restaurants and healthcare providers are expected to be among the most avid adopters of the technology.

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While touchscreen interface-based solutions are finding their way into every imaginable device, unfortunately they do not provide a satisfactory user experience in many fields. In general, users have difficulty entering data and are frustrated by low accuracy rates and mis-touches. For example, gamers need to split their attention between game play and the user interface when using touchscreens. For example, tablets are regarded as mostly content consumption devices instead of content creation devices due to these limitations. As such, in business environments, Gartner analysts expect touch-enabled devices to have a slower adoption rate in the enterprise arena because they cannot meet the intensive requirements for typing and text input.

If not addressed, these problems will only escalate, requiring users to compensate for the lack of tactile feedback by employing external devices or software-based aids. Unfortunately, many manufacturers have not made tactile feedback for touchscreens a priority or realized the long-term impact of not having it – partly because of the lack of viable solutions.

What manufacturers need is an easy to integrate, cost-effective feedback mechanism for touchscreens that provide true tactile feedback while still maintaining the best features of these interfaces.

The solution exists: The purpose of this white paper is to inform manufacturers, developers, display firms and others about the operation and benefits of the Tactus Tactile Layer surface - in particular, how it can be used to provide users with an unparalleled tactile touch experience while also addressing software developers’ needs to create truly innovative products.
Several situations highlight the critical need for touch-enabled devices to integrate some form of tactile feedback that allows users to interact easily with them.

**Accuracy and Ease of Use**

Numerous studies have demonstrated how touchscreens consistently contribute to slower and less accurate performance in comparison to keyboards.\(^5\) Results demonstrate how users can only type about 25 words per minute with a touchscreen keyboard compared to 58 words per minute using a standard keyboard.\(^6\) Data entry errors, poor typing speeds, mistouches and low accuracy makes touch-screen based devices unsuitable for serious content creation.

**Safety**

The need to constantly look at touchscreens to confirm input also gives rise to another set of problems. A growing number of automotive manufacturers are integrating touchscreen-based solutions into their latest vehicles.

People are using touchscreen-based panels within their cars and media players – which offer great convenience but also pose severe safety issues. Visual interfaces in the car demand significant driver attention due to the lack of tactile feedback. Decreased ability to maintain a constant lane position and taking a large number of short glances were only some of the effects of using touchscreens.\(^9\)

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\(^8\) Ambient Touch: Designing Tactile Interfaces for Handheld Devices, Ivan Poupyrev 1, Shigeaki Maruyama 2 and Jun Rekimoto 1

\(^9\) The effects of using a portable music player on simulated driving performance and task-sharing strategies, Kristie L. Young
There’s plenty of evidence to show how eye glances away from the road contribute to 60% of near-crashes, crashes and incidents.\textsuperscript{10} According to the National Highway Traffic Safety Administration (NHTSA), 5,474 people were killed in crashes involving driver distraction, and an estimated 448,000 were injured in 2009. In 2010 alone, over 3,000 people were killed in distracted driving crashes.\textsuperscript{11}

The NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Device intends to prohibit any action that requires the driver to takes their eyes off the road for more than two continuous seconds and calls for ‘near-static’ displays.\textsuperscript{12} Introducing haptic feedback to provide confirmation of inputs should significantly reduce the need to glance at the interface.

\textbf{Accessibility}

In November 2009, Syracuse University and the University of Wisconsin-Madison rejected the Amazon® e-reader, the Kindle® DX, as a textbook replacement in their classrooms because they weren’t accessible to blind students.\textsuperscript{13} Authorities at the National Federation of the Blind applauded their decision stating that the device in its current form “denies the blind equal access to electronic textbooks.”

Music icon Stevie Wonder requested designers at the 2009 Consumer Electronics Show to improve touchscreen accessibility for the blind and visually impaired.\textsuperscript{14} A class-action lawsuit was filed by LightHouse for the Blind and Visually Impaired against videodisc rental service Redbox®, because their touchscreen-based kiosks weren’t accessible to the visually impaired.\textsuperscript{15}

\begin{footnotesize}
\textsuperscript{11} \url{http://www.distraction.gov/content/get-the-facts/facts-and-statistics.html}
\textsuperscript{12} \url{https://www.federalregister.gov/articles/2012/04/25/2012-9953/visual-manual-nhtsa-driver-distraction-guidelines-for-in-vehicle-electronic-devices}
\textsuperscript{13} Reisinger, D. Universities reject Kindle over inaccessibility for the blind. CNET (2009). \url{http://cnet.co/gSjyv9}
\textsuperscript{14} Carew, S. Touch-screen gadgets alienate blind. Reuters (2009). \url{http://reut.rs/gHi5X}
\textsuperscript{15} Consumer Digest \url{http://www.consumersdigest.com/news/spread-of-touch-screen-technology-worries-advocates-for-visually-impaired}
\end{footnotesize}
Inaccessible touchscreen based devices present severe accessibility barriers to millions of blind people as well as the visually impaired, seniors and those lacking fine motor skills due to diseases such as Parkinson’s and arthritis.\textsuperscript{16}

As more devices incorporate touchscreens without feedback mechanisms, visually impaired users need to find alternative accessible interfaces (if available), use expensive software aids, request help from others or resign themselves to being unable to use them altogether. In the long-term, it could prevent them from performing their job, sharing gadgets, doing routine tasks and accessing information in public areas.

**Health**

A new breed of touchscreen-related repetitive stress injuries is also being observed. Virtual keys don’t react when depressed and users strike them with eight times as much force as they tap real keys, straining the forearm, wrist and fingers. Holding fingers in a hovering position above the keyboard also causes isometric tension, which stresses the tendons and muscles.\textsuperscript{17}

\textsuperscript{16} Kane, S. K., Jayant, C., Wobbrock, J. O., and Ladner, R. E. Freedom to roam: a study of mobile device adoption and accessibility for people with visual and motor disabilities. ASSETS ’09, 115-122.  
\textsuperscript{17} http://www.infoworld.com/t/laptops/the-hidden-danger-touchscreens-181774
How The Tactus Tactile Layer Surface Works

Easy to integrate, the tactile panel replaces the glass or plastic layer that sits on top of the touch sensor and display on a touchscreen. It is essentially a thin, flat, smooth and transparent cover layer varying in thickness from about 0.75mm to 1mm that has certain special properties.

Made of a thin multi-layer stack, the top-most layer consists of an optically clear polymer. A number of micro-holes connect the top layers of the panel to a series of micro-channels that run through the underlying substrate. The micro channels are filled with a fluid whose optical index of refraction matches that of the surrounding material, making it fully and evenly transparent when light from the display passes through.

Increasing the fluid pressure causes the fluid to push up through the holes and against the top polymer layer, making it expand in pre-defined locations. This enables an array of physical and completely transparent buttons to rise out of the surface. A small internal controller that interfaces with the processor of the touchscreen device controls the rise and fall of the buttons. The controller allows a proximity sensor or a software application to control the state of the buttons. For example, the buttons could be triggered to rise whenever the software calls for the virtual QWERTY keyboard.
TECHNOLOGY OVERVIEW

It takes less than one second for the buttons to rise or recede. Once formed, the buttons are stable and users can rest their fingers on them or type on them just like a regular keyboard. When the buttons aren’t needed the controller triggers a reduction of the fluid pressure. The buttons recede back into the Tactile Layer panel and the surface becomes smooth and flat again. The panel size as well as the size, shape and firmness of the buttons are fully customizable. Buttons can be of any shape – circles, rectangles, ovals, squares, long thin lines, or even ring- or donut-shaped. Their height (from high to low) and feel (from soft to rigid) can be precisely controlled.

It is possible to create almost any type of button configuration or layout on a panel, and that configuration is set in the manufacturing process. Multiple button sets can also be pre-configured on a single panel, enabling different groups of buttons to be raised at different times, depending on the interface needs of the user.

Power requirements of the Tactile Controller used to actuate the panel are minimal. The system only consumes a small amount of power to raise or lower the buttons. Once the buttons are raised, they remain enabled for as long as they are needed – be it a few seconds or several hours – without any additional power consumption. This is possible because the pressure used to raise the buttons remains present, causing the buttons to automatically pop back up each time they are pushed. In contrast, haptic vibration-based solutions consume battery power each time a vibration is made.

Covered by multiple core patents, Tactus’ technology enables real, physical buttons to rise out of the surface of a touchscreen when needed and recede back into the surface when done.

Coatings similar to those used on touchscreens can also be used on the tactile surface to make it anti-fingerprint and scratch proof. Even if the touchscreen cracks, the tactile surface will function normally if it isn’t damaged since it is independent of both the touch sensor and the LCD screen.
Tactus Enables Effortless Human Device Interaction

For any touchscreen-based solution to accomplish the goal of effortless human device interaction, it must fulfill these criteria:

- **Addresses Orientation And Confirmation** – Two of the biggest problems faced by touchscreen technology developers are issues of orientation and confirmation - the ability for a user to know finger positions on a flat screen and their ability to know when an input has been made. Vibration-based haptic solutions attempt to address only the confirmation challenge by vibrating the device to mimic a key depress. By creating actual physical buttons that users can see, feel and depress, Tactus solves both issues in one solution.

- **Enables Users To Rest Fingers On Screen Without Inputting Data** – Currently, it is impossible for users to rest their fingers on the surface of a touchscreen because each touch is always registered as a data input. The Tactus solution allows users to rest their fingers on the buttons because their fingers are further away from the touch sensor than when the buttons are pressed or retracted. Tactus’ technology lets users orient or reposition their fingers onscreen by feeling for the buttons or button edges and fine-tuning finger positions, without needing to glance at the screen.

**The Bottom Line:** Tactus provides a next-generation tactile surface for touchscreens that meets these criteria. The Tactus Tactile Layer panel is the only solution that can generate a keyboard (or arbitrarily-shaped buttons) on-demand on the surface of any touchscreen. This allows manufacturers to create accessible, truly efficient touchscreen-based systems in a cost-effective manner while improving the lives of users and enabling them to do far more with their devices.

Tactus’ Tactile Layer panel with a raised QWERTY keyboard button layout.
CONCLUSION

Maintaining a competitive edge in today’s display and touchscreen-enabled markets requires manufacturers to provide consumers with a superior user experience in a stylish solution that combines practicality with a “Wow factor”.

To meet consumer’s high expectations, manufacturers need to continually innovate, think outside the box and use solutions that allow them to rise above the competition.

Tactus has developed a revolutionary user interface technology that adds a new dimension to touchscreens and allows manufacturers to dramatically differentiate their devices. This is accomplished in a highly competitive market by providing the best of both touchscreen and button technology. For the OEM/ODM, there is no need to sacrifice function over form or to compromise their display technology in any way – Tactus conforms to all displays of any shape or size.

To summarize, here are 6 key benefits of integrating the Tactus Tactile Layer component:

• **Ease of Use Enables Deeper Penetration Into Existing Markets:** Being able to touch type on Tactus-enabled devices or to blind navigate makes it possible for devices to be used for a greater number of user applications and markets. For instance, users can now use tablets as effective content creation devices.

• **Opens Up New Markets:** Physical buttons wear out, fail or become repositories for dust and dirt over time. With Tactus-enabled devices, users get the best of both worlds – a keyboard-on-demand without the previously described issues. These devices are also easy to sanitize, opening up medical and public safety applications where transmission of diseases via shared use of keyboards is an issue.

• **Improves User Experience Significantly:** Tactus-enabled products allow for real touch-typing, faster typing speeds and higher accuracy while reducing data errors, eliminating hand hovering and registering mis-touches.

• **Allows For Creation Of New, Innovative Devices:** Existing devices could be made portable or lighter with Tactus because it allows the screen and the keyboard to be combined into a smaller system. Manufacturers can do away with a dedicated space for buttons on a device allowing the screen size to be bigger. Industrial designers have the option to use Tactus technology innovatively on curved surfaces or for aesthetic reasons instead of physical buttons.
• **Easy to Integrate:** Manufacturers do not need to re-engineer their display stacks – the Tactile Layer panel simply replaces the front layer of the display stack, known as the cover lens or window. The layer is the same thickness as the layer it replaces and requires little or no change to the underlying touch sensor or display. The size is scalable from that of a mobile-phone screen to a TV screen. It works with existing touch sensing and display technologies, consumes little power, and offers customizable button locations, shapes and layouts.

• **Improves The Accessibility Of Touch-Enabled Devices:** With Tactus-enabled products, the visually and physically impaired can feel real physical keys, dramatically increasing their ability to use mobile and CE devices.

Find out how Tactus Technology can help you create more innovative products. For more information, visit our website at [www.tactustechnology.com](http://www.tactustechnology.com) or email [sales@tactustechnology.com](mailto:sales@tactustechnology.com) or call: +1 650-918-7509

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**About Tactus Technology, Inc.**

Tactus Technology is the developer of a breakthrough dynamic user interface for CE, mobile and automotive devices – completely transparent physical buttons that rise up from a touchscreen surface on demand. In December of 2011, Tactus closed $6M in Series A funding in a round led by Thomvest Ventures, with participation from other corporate and private investors. Tactus works with device manufacturers to integrate the Tactile Layer™ panel into a variety of touchscreen devices. Tactus Technology is headquartered in Fremont, CA. For more information, visit [www.tactustechnology.com](http://www.tactustechnology.com) or follow @tactustech on Twitter®.

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