TOUCH INTERNATIONAL

TOUCH INTERNATIONAL

TOUCH TECHNOLOGY FOR MILITARY APPLICATIONS:

An Insider's Guide to Choosing the Right Touch for Your Display

Gary L. Barrett, Chief Technology Officer at Touch International
Jamie Sewell, Touch International

Graphics By:
Kelly Leff, Touch International

CHOOSING THE RIGHT TOUCH TECHNOLOGY CAN BE DAUNTING FOR EVEN THE SEASONED TECHNOLOGY GURU.

With over 1,200 touch-related patents in existence, it is easy to become confused about which touch technology to choose to integrate into a new product.

For the military or aerospace engineer, the process of choosing the right touch technology becomes even more difficult. Not only must the touch screen perform well in controlled settings, but also in extreme environments with unknown variables ranging from vibration to noise to extreme temperatures. With touch screens finding their way into cockpits, MRAP vehicles, handheld navigation units, and countless other devices, it is absolutely critical that these displays perform 100 percent of the time.

So how do mil/aero manufacturers choose the right touch technology? Just like any other project, it is important to first carefully evaluate the needs of your product and the environment of the display. Once your key requirements have been identified, it becomes much easier to weigh the advantages and disadvantages of each technology to find the touch screen that is right for your application.

It is also important to consider incorporating value-added solutions like EMI shielding, LCD heaters, display enhancements and optical bonding into your mil/aero display. To expect the right touch technology to perform in a challenging mil/aero environment without assistance from value-added solutions is most likely not the case. Once we have discussed how to choose the right touch technology for mil/aero applications, we will look at how enhancements and other solutions are built on top of, inside of, or behind the touch panel to help the finished product perform in adverse situations.

In this guide, we will examine the touch technologies best suited for mil/aero applications, identify the strengths and weakness of each, and discuss what applications each technology might be suited for. We will then explore the role that display enhancements and value-added solutions have in addressing potential display challenges within mil/aero environments.

PLANNING YOUR PROJECT

Once you begin taking steps to put a touch product into production, it is important to examine the factors below to identify which touch technologies will be good for your application, as well as the ones to avoid:

- ***Size –*** *What size does your application require?*
- ***Capabilities –*** *What type of functionality is needed?*
- ***Input Method –*** *Finger, Stylus, Glove?*
- ***Number of Points –*** *Single-Touch, Dual-Touch, Multi-Touch?*
- ***Environment –*** *What conditions will it be subjected to?*
- ***Durability –*** *How long does it need to last?*
- ***Complexity –*** *Does my project need a standard display or custom design?*
- ***Regulatory Restrictions –*** *Are there any industry regulations I need to consider?*
- ***Availability –*** *Will it be available in the future if I need replacements?*
- ***Cost –*** *What is my budget for adding touch to this product?*
- ***Power Consumption -*** *How critical is a few milli-watts of power?*

Once you've answered these questions, you will be better prepared to identify touch technologies that fit within your requirements. It is important to keep in mind that there is no such thing as a perfect touch solution. While the goal of every manufacturer is to produce indestructible touch screens that last forever, have perfect optical clarity, are immune to interference, and cost nothing, the reality is that each technology has strengths and weaknesses, so it is important to explore all options and make an educated choice based on your requirements.

WHAT ARE MY OPTIONS?

Before diving in head first, let's take a look at the touch market as a whole. What does the big picture look like? What technologies are mature and market-proven, and which ones are still emerging?

There are many touch technologies in the market; however most have proven to be niche products, too expensive, not reliable or difficult to produce. Below is a summary of the top touch technologies, with projected capacitive and analog resistive making up 90% of the total market share.

Top Five Touch Technologies in the Market Today

Projected Capacitive	[Increasing Market Share]
Analog Resistive	[Flat Market Share]
Surface Capacitive	[Decreasing Market Share]
Infra-red (IR Touch)	[Flat Market Share]
Surface Acoustic Wave (SAW)	[Decreasing Market Share]

Additional Touch Technologies

- *Optical Touch*
- *Multi-Touch Analog Resistive (AMR or MARS)*
- *Dispersive Signal (DST or Bending Wave)*
- *In-Cell/On-Cell Touch*
- *Acoustic Pulse Recognition (APR)*

Of the touch technologies in the market, only a few are actually viable options for most mil/aero applications. Choosing the right touch technology is often very application specific; so while projected capacitive may be an excellent option for in-flight entertainment, it may not be the best choice for cockpit controls (yet). An important caveat to the information below is that improvements are happening very quickly and soon, some of this will be inaccurate.

Top Touch Technologies for Mil/Aero Applications

- *Analog Resistive*
- *Projected Capacitive*
- *Multi-Touch Analog Resistive (AMR or MARS)*

Additional Touch Technologies

- *Infra-red (IR Touch)*
- *In-Cell/On-Cell Touch*

ANALOG RESISTIVE

Advantages	Limitations
Low Cost Solution	Not as Durable as Other Technologies
Lowest Power Consumption	Requires Periodic Recalibration
Unaffected by Dirt, Water, Light & Most EMI Noise	Lower Transmittance & Optical Quality
Works with Finger, Glove & Any Pointing Device	Not True Multi-Touch Capable
Easy to Integrate	

For twenty years, analog resistive reigned supreme, but fell to the #2 spot in 2010 when it was unseated by projected capacitive. At one point in time it could even be said that there were more analog resistive touch screens manufactured in one day, than all other touch technologies combined in one year.

Even though projected capacitive has replaced it as the most widely produced technology, resistive still has an important place in today's market and should not be overlooked.

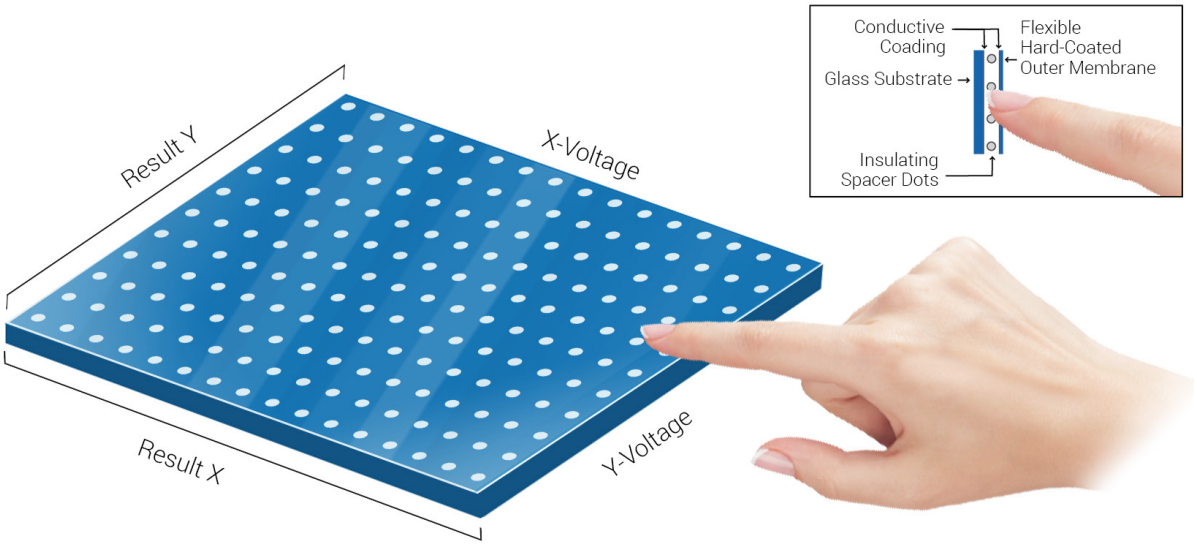
For mil/aero applications, resistive is still a solid choice, primarily because it is pressure sensitive, meaning the input device must physically make contact with the top sheet which will then make contact with the conductive side of the glass, closing the electrical circuit, resulting in a touch. Unlike some other technologies, there is essentially no chance of having a false touch with resistive.

It is important to note, however, that the user experience with resistive, as compared to the projected capacitive iPhone or iPad experience is not the same, partly because the touch screen requires actual pressure, and partly because the touch panel does not work with gestures and graphical images in the same way.

How it Works

There are five types of resistive technology defined by the signal lines and include 3-wire, 4-wire, 5-wire, 6-wire and 8-wire touch screens. Today, Touch International most commonly builds 4-wire (lowest cost) and 5-wire (most durable). Generally, all resistive touch screens consist of a glass layer with an ITO conductive coating on top and a polyester top sheet with a conductive coating on the bottom. The conductive surfaces are held apart by "spacer dots" - usually glass beads that are silk-screened onto the coated glass. In the case of 5-wire, a toggled voltage is applied to the 4 corners of the glass layer, and when a person presses on the top sheet, its conductive side comes in contact with the conductive side of the glass, effectively closing a circuit (this is called pressure sensing). The voltage at the point of contact is read from a wire connected to the top sheet, which is the fifth-wire.

The image below represents a basic illustration of how this technology works.



Reference: *http://www.cnintech.com/blog/Interactive-Whiteboard_2015072401.html*

For 4-wire, the glass layer has two conducive buss bars on either side of glass layers, and on the top, two conductive traces perpendicular to the two on the below. A plus voltage, and opposite side ground are put first on the ITO glass layer, which has a uniform resistance between the buss bars. The voltage is read at the point where the top layer pushes to the bottom, passed through an analog-to-digital converter to get the X coordinate. Then the voltage is applied to the top layer and read back by the bottom layer to get the Y coordinate. This toggling is repeated more than 100 times a second to get very fast, high resolution coordinates.

Top 3 Reasons to Choose Analog Resistive

- ***Pressure Sensitive -*** *Virtually any object can be used to activate the sensor, including a finger, pencil, tool, or glove, making it ideal for applications requiring full input flexibility. This is a key feature for mil/aero applications, as thick gloves are often worn in these environments.*
- ***Unaffected by Elements -*** *Because it is activated by pressure, resistive displays will not be affected by dirt, water, light and most EMI noise, making it ideal in rugged, outdoor applications.*
- ***Lowest Power Consumption -*** *Resistive systems consume a very small amount of electricity because power is only consumed when the sensor is actually being touched, making it a good choice for battery powered units.*

Additional Benefits & Capabilities

- *In some applications, the purchase of additional electronic components may not be needed because many ASICS (application-specific integrated circuit), including LCD ASICS, often include a touch screen controller as part of its circuitry.*
- *The resolution of the sensor is very good so it can adapt well to written input, making it a logical choice for many writing or character recognition applications.*
- *Highest coordinate (touch) output of any technology, which can exceed 300 frames a second.*

Disadvantages

- ***Durability -*** *The durability issue comes from the flexing and rubbing of the ITO which breaks or wears out the ITO, which is only a few angstroms thick. This can be a major drawback, especially if the display is deployed in the field, or not easily accessible.*
- ***Recalibration -*** *Because of its analog signal, resistive must be periodically recalibrated.*
- ***Optical clarity -*** *The multiple air gaps within the sensor are reflective which reduces the light transmission and degrades the image.*

Recommended Applications

Resistive touch is well suited for almost any mil/aero application, especially anything requiring the use of thick gloves, such as military vehicle navigation equipment, handheld radios, or ruggedized laptops.

PROJECTED CAPACITIVE

Advantages	Limitations
Long Life Span	Doesn't Work with All Glove or Stylus Inputs
Excellent Optical Properties	Sizes Larger than 22" are Expensive to Build
Multi-Touch	Systems Must be Initially Tuned
Highly Reliable & Durable	Can be Affected by EMI & Emit EMI
Operates in Environmental Extremes	Can be Difficult to Integrate
No Recalibration Needed	
Low Power Consumption	

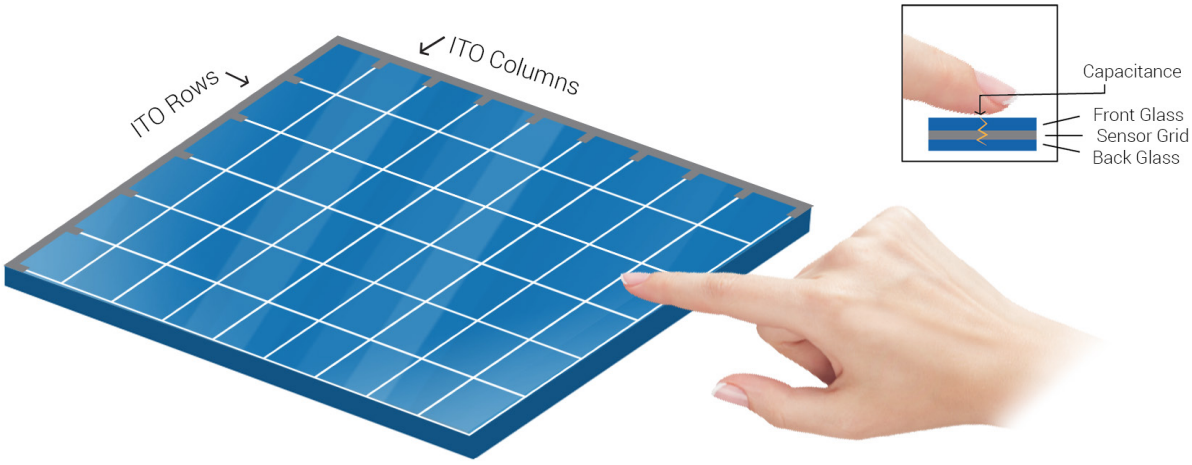
Since the release of the iPhone in 2007, the demand for projected capacitive (also called p-cap, pro cap, or PCT) has seen steady growth, especially in mobile devices, and is now the most popular technology for today's touch products.
Within the mil/aero market, however, projected capacitive has a few issues that will need to be resolved before it will become the top touch technology for mil/aero applications.

HOW IT WORKS

In the short time since the introduction of projected capacitive touch screens in the iPhone, a myriad of construction methods have been developed. All projected capacitive touch screen designs have two key features in common - the sensing mechanism (ITO layer) that lies behind the touch surface and the use of no moving parts.

Mutual capacitance is now the more common projected capacitive approach and makes use of the fact that most conductive objects are able to hold a charge if they are very close together. If another conductive object, in this case a finger, bridges the gap, the charge field is interrupted and detected by the microcontroller.

Projected Capacitive touch screens are "scanned", meaning that most of these touch screens are made up of a matrix of rows and columns that are "read" one by one to get a reading or count. To get an exact coordinate, the results from several row/column intersections are read and the counts used to triangulate the exact touch location. The illustration below shows the rows and columns made by the ITO and a very basic stack-up design with the ITO layer protected by glass on both sides.



Top 3 Reasons to Choose Projected Capacitive

- ***It Will Never Wear Out (Potentially) -*** *The ITO layer (conductive coating) of the sensor cannot move and is well protected, giving the sensor the potential to last forever. The display will likely wear out before the touch screen. The durability of projected capacitive is ideal in a mil/aero application where the display may be used for 15 years or more.*
- ***Accurate Touch -*** *Touch point accuracy is very high and drift-free, with no recalibration needed.*
- ***Ultimate Design Flexibility -*** *Projected capacitive is typically available in a standard all-glass design, but film-glass and all-plastic configurations are also available. The all-plastic versions can be made with a flexible construction to fit curved surfaces, and are virtually unbreakable and very light weight.*

Additional Benefits & Capabilities

- *Second only to infra-red touch (which has nothing in front of the LCD), projected capacitive offers the best image clarity and light transmission.*
- *The number of input points the touch screen can recognize is potentially unlimited, but is dependent upon the controller to relay those points back to the computer; ten input points is typical.*
- *Proximity sensing is possible up to 6cm (typical) from the display.*
- *It can work with water spray and on-screen contaminants.*
- *Works with varying thicknesses of cover glass, allowing for a flush front (seamless) finish like one would see on the iPhone, or behind the very thick glass of a store front window.*
- *There are many vendors for reliable projected capacitive electronics.*

Disadvantages

While the advantages of PCAP are many, for mil/aero, there are still a few issues that need to be addressed before it will be the number one choice for mil/aero.

- ***Lacks Full Input Flexibility -*** *While the firmware for the touch screen can be tuned to be more sensitive to thick gloves or passive pen input, projected capacitive does not offer the same input flexibility of analog resistive, which for some mil/aero applications could be problematic.*
- ***Noise -*** *Projected capacitive displays emit EMI (electro-magnetic interference) and can also be susceptible to EMI. This disadvantage can be overcome through the use of EMI shielding, EMI mesh and EMI gaskets. Resolving EMI or noise issues will be discussed further in the second section of this paper.*

Recommended Applications

For mil/aero applications requiring high optical clarity, multi-touch capabilities or long lasting durability, projected capacitive is an excellent option. Its ease of use and advanced GUI capabilities make it ideal for any kind of imaging application, including mapping or surveillance equipment. Mobile devices, navigation equipment, in-flight entertainment, and command post information displays are additional applications where projected capacitive is well suited.

MULTI-TOUCH ANALOG RESISTIVE

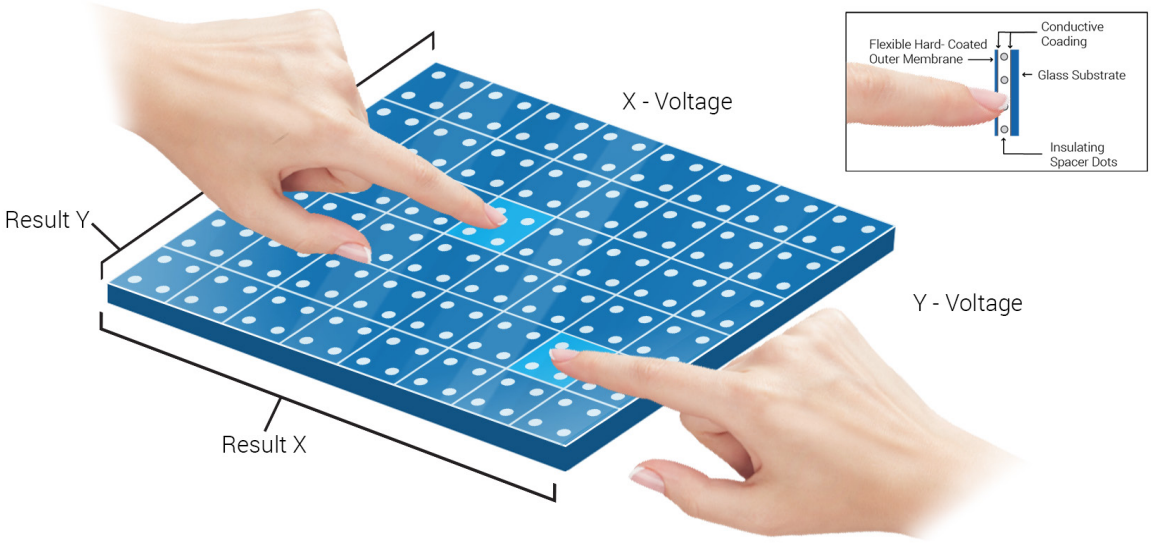
Advantages	Limitations
Multi-Touch (Up to 10 Input Points)	Not as Durable as Other Technologies
Low Power Consumption	Lower Transmittance & Optical Quality
Unaffected by Dirt, Water, Light & Most EMI Noise	Cost is Higher than Typical Resistive
Works with Finger, Glove & Any Pointing Device	Requires Large Connecting Tail
Easy to Integrate	

Multi-touch analog resistive, also called MARS, MAR or AMR, is a newer way to achieve true multi-touch for applications that require the ability to use any probe, glove, or non-body activation. This technology can be thought of as replacing one standard analog resistive touch surface with a multitude of tiny, finger-tip size, touch panels on a single touch surface. Each of these tiny touch panels will report analog output, so writing on the touch surface will result in the same high-resolution “ink” you would expect from a single touch analog resistive touch surface. Because this technology is a cross between a digital and analog sensor, the result is more accurate than a traditional analog resistive system which can suffer from “drift” in the touch

coordinate. In addition, this technology allows you to solve the “palm rejection” problem by only looking at input from the area where writing is involved.

HOW IT WORKS

The construction of MARS is similar to that of regular resistive, and is essentially a 4-wire resistive sensor cut up into many small 4-wire touch screens. Unlike traditional resistive, however, MARS is made up of an X-Y grid which is scanned. The advantage of this technology is that it provides multi-touch abilities, while still allowing for input from any pointing device because it is pressure sensitive.



Top 3 Reasons to Choose MARS

- ***Input Flexibility -*** *The touch sensor can be activated by virtually any input device including bare fingers, gloved fingers, and any pointing device, including a stylus, scalpel or pencil.*
- ***High Resolution & Palm Rejection -*** *The technology's high-resolution screen and palm rejection allow for easy note-taking, making it ideal for tablet pc applications.*
- ***Multi-User Input -*** *With its multi-touch capabilities and flexible input options, MARS is an alternative to PCAP, and is ideal for multi-user input in industrial applications or interaction between a pilot and co-pilot in an airplane cockpit.*

Other Reasons to Choose MARS

- *MARS is not affected by surface contaminants, making it a viable option for marine applications where water, dirt and other contaminants may be on the screen. Unlike some other technologies, MARS is not activated by water or other on-screen contaminants.*
- *Areas of the sensor can be deactivated to solve for the "palm rejection" problem.*
- *A "z" component, or pressure measurement, is possible. Some signature capture software requires pen pressure as a component of the recognition algorithm*.

For mil/aero applications, MARS is an excellent option and carries all of the same benefits of analog resistive with the added benefits of multi-touch input, and without the need for recalibration. Compared to projected capacitive, however, the display image is not as nice and the sensor will not have the same life expectancy.

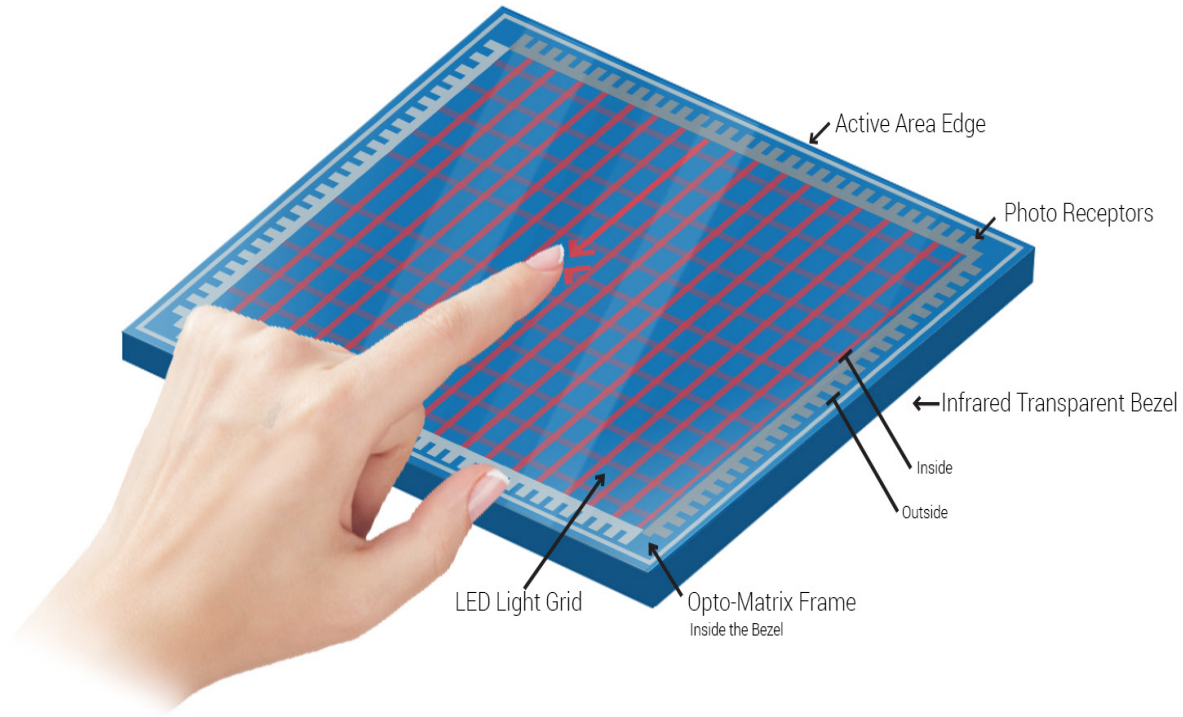
Recommended Applications

Like traditional analog resistive, MARS can be used for essentially all mil/aero applications, including multi-user functions. Examples of multi-user applications in a mil/aero setting would be multiple people examining parts of a map, or two a driver and passenger manipulating navigation information in a military land vehicle. Applications that use writing or typing, such as a field tablet, will benefit from this technology.

INFRA-RED TOUCH TECHNOLOGY (IR)

Advantages	Limitations
Long Life	Limitations on Integration with the Display
Stable Drift-Free Operation	Vulnerable to Surface Contaminants & Water
Works with Finger, Glove & Any Pointing Device	High Cost
High Transmission & Optical Clarity	Low Resolution
Adapted to Large Format LCD's	

Infra-red touch is one of the oldest touch technologies and remains a survivor. Today it can be found in public access kiosks, point-of-sale terminals, and big displays.



Reference: *http://informationdisplay.org/id-archive/2009/december/frontline-technology-high-volume-manufacturing-of*

How it Works

IR uses a Printed Circuit Board (PCB) "frame" around the perimeter of the display. On two sides there are closely spaced IR LEDs - the opposing two sides have matching photo transistors. The LEDs are turned on in sequence and the signal is read from the photo transistor to the matching transistor. If no signal is read, then that indicates a blocked IR beam, meaning a touch. No actual touch "screen" is required for operation; however a plate of glass is generally used to protect the underlying display from damage and to provide anti-glare properties.

Here are the advantages:

Top 3 Reasons to Choose IR

- ***Best Optics -*** *With nothing needed in front of the display, there is nothing to degrade the optics. Keep in mind, however, a transparent window is typically put in front of the display to protect it from damage.*
- ***Large Format Available -*** *It has been adapted to very large (62 inch) displays and has found its current niche in this domain.*
- ***Input Options -*** *It will respond to any probe… pencil, glove or tool; however very thin input devices may not work because it needs to have a large enough point to interrupt the light signal.*
- ***Muti-Touch -*** *Recent improvements to IR sensing technology have introduced true multi-touch to this technology; however this application requires a lot of computing power and sophisticated software.*

Additional Benefits & Capabilities

- *Until the advent of projected capacitive touch, IR was the longest lasting of the touch technologies and is also chosen for its durability.*
- *Although costly, it may be one of the best technologies for night-vision applications.*

For most mil/aero applications, IR is not the best option because it is difficult to integrate and is susceptible to interference from sunlight, water, dusty and other surface contaminants blocking the IR beams.

The primary mil/aero application where IR Touch can be used is in central command posts to view and manipulate digital maps and images on a large format display. Another good large-format option for similar applications is Optical Touch. Information on how Optical Touch works can be found in Touch International's whitepaper, Decoding Touch Technology.

IN-CELL/ON-CELL TOUCH

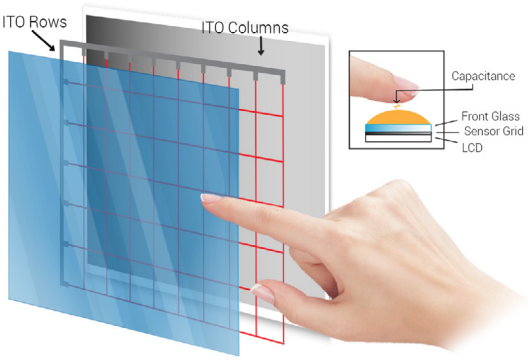
Advantages	Limitations
Very Accurate	High Power Consumption
No Drift and no Calibration Needed	Very Expensive
Unlimited Touch (Controller Dependent)	Low Durability
Thinner Display	Cover Glass not an Option
	Inflexible, Few Suppliers

Twenty-five years ago it was thought that spoken inputs would replace touch. Today, however, building touch into the LCD is thought to be the killer of touch screen companies.

Although there are some on-cell LCD's that can be found in the market, today, this is not a technology that you could choose for mil/aero products. Samsung and Microsoft have jointly developed a new table size in-cell system, and the new Apple iPhone is expected to incorporate this technology as well.

Top Reasons to Choose In-Cell/On-Cell

- *Elegant display of new technology*
- *Large formats available*
- *Up to 50 touch points*

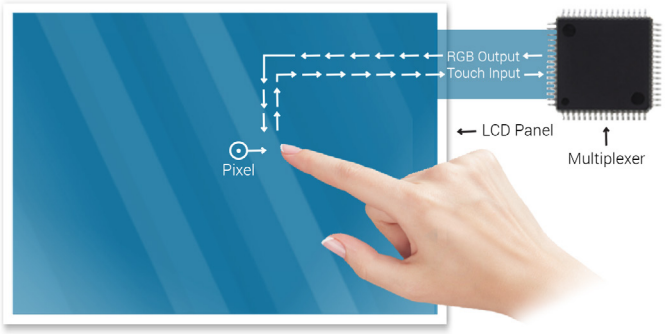


ON-CELL

How it Works

On-cell simply means that the transparent conductors used to make a separate projected capacitive touch panel are instead incorporated into the LCD layers, essentially adding a projected capacitive sensor to the layers of the LCD.

In-cell touch means that something in the LCD pixel is touch sensitive, usually photo-sensitive, though it could be self-capacitance type projected capacitive. This is done by scanning the pixels and reading the input back through the drive multiplexer. Thus, the multiplexer both changes (drives) the color pixel and then reads the touch input on the pixel (receives).



IN-CELL

While In-Cell/On-Cell holds promise and could provide some definite advantages for mil/aero displays, this technology is a long way off from being a viable option for mil/aero applications.

TOUCH TECHNOLOGY SUMMARY

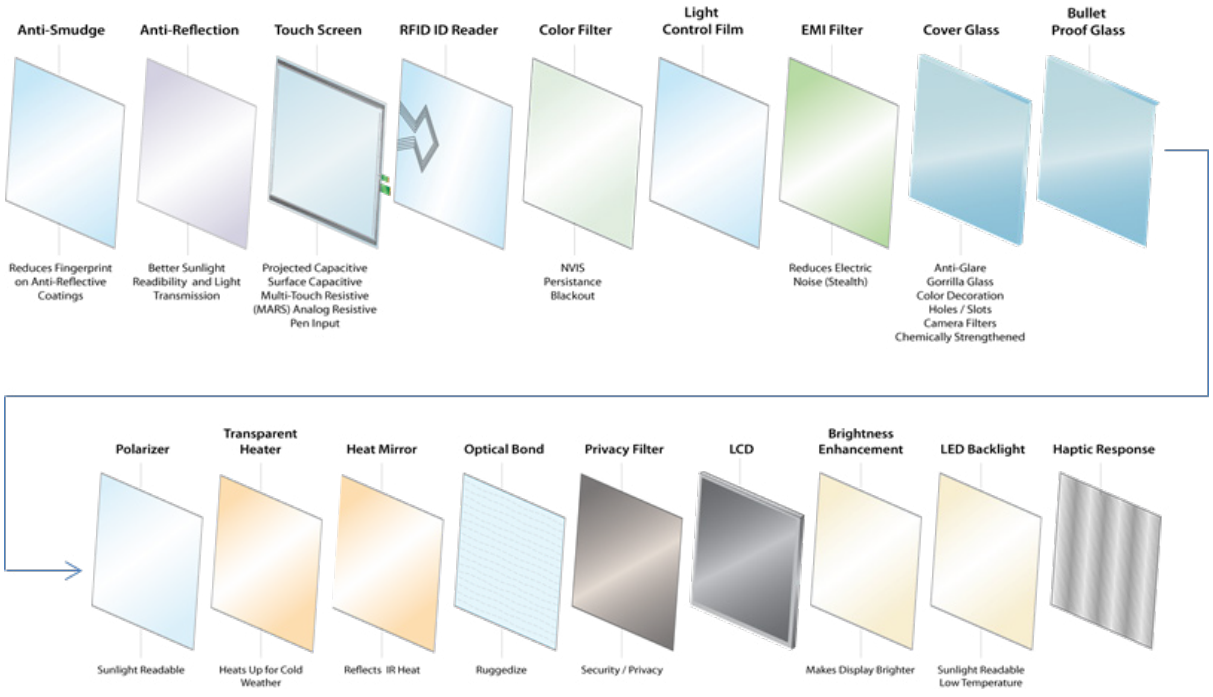
While there are many good touch technologies in the market, it is important to recognize that there is no perfect technology, and there are distinct advantages and disadvantages to each. In addition to choosing the right touch technology for your mil/aero application, you will want to consider the envi-ronment of the display and the environmental factors that may affect it. Depending upon the challenges your mil/aero display may face, you should consider the use of display enhancements and value-added solutions, which we will discuss in the next section.

DISPLAY ENHANCEMENTS AND OTHER VALUE-ADDED SOLUTIONS

Today's mil/aero touch screen does more than simply facilitate touch; it is often expected to suppress noise from the LCD, reduce glare from the sun, keep the display warm in freezing temperatures, reduce heat in extreme temperatures, and the list goes on and on.

In this section, we will examine display enhancements and other value-added solutions that can optimize displays in a mil/aero environment, and some of the reasons one would use these solutions. It is important to note, that these enhancements may also be added to a non-touch display window and do not require touch screen integration.

Enhancement solutions fall into three general categories: 1) controlling electromagnetic interference (EMI), 2) optics to manipulate the physics of light, and 3) improvements to the environmental integrity of a display. The image below illustrates just some of the enhancements that are used within today's military displays.



EMI FILTERS

Electromagnetic Interference Filters are designed to reduce emissions in the radio frequency (RF) range of the electromagnetic spectrum. At the lowest levels of emissions, the U.S. Federal Communications Commission (FCC) and the Conformite Europeene (CE) in Europe, require manufacturers of electrical equipment to limit the levels of RF emission. The FCC has two categories: Class A for electrical equipment used in offices and Class B for home use, which is more restrictive and does not allow any interference with radio or television operations. At the extreme end of concern are so-called "Tempest" limits, which seek to stop enemies from scanning remote devices and conducting espionage. These are so restrictive one cannot even know what is needed to meet the filter requirements without high level security clearance. In between are filters, primarily for military or aerospace environments that seek to stop interference with navigation instruments or limit the ability of "enemy sniffers" to find and target a location.

Within the RF range, the filters can be tuned for specific frequencies, and the filter that is good at blocking one frequency, may be less effective for another. For this reason, Touch International offers two EMI filter types, low Ohm Indium Tin Oxide (ITO) and blackened mesh. Touch International's EMI filters can be tuned to specific frequencies, and when tested per MIL-STD-285, can approach attenuations of 70 dB (15KHz), 80 dB (10 MHz) and 20 dB (1 GHz).

In the case of minimizing EMI, touch panels and display windows are also often relied upon to mini-mize noise coming from the LCD, and work to allow flat panel displays to satisfy FCC and MIL-STD-461 requirements.

ENHANCEMENT FILMS & FILTERS FOR LIGHT OPTICS

Enhancement filters and films are used to manipulate emissions in the 400 nm to 700 nm range, (visi-ble light) and in the 700 nm to 1200 nm, (near infra-red or NIR). These enhancements mostly seek to manipulate the properties of light, which may include blocking or enhancing the radiation. Touch International offers a variety of finishes including polarizers, retarders, Broad-Band anti-reflective, and light control film. From

cockpit controls to vehicle navigation to hand-held devices, these light-manipulating enhancements play a key role in boosting display brightness and clarity, as well as restricting images when needed.

ANTI-REFLECTION (AR) COATING

Anti-Reflective (AR) coatings dramatically reduce surface reflections and allow for better sunlight readability, improving the brightness and contrast ratio by up to 300% without requiring additional power.

Anti-reflective coatings are stacks of very thin films of chemicals coated onto the glass (or plastic) surface. When the film stack is properly designed, light entering the film stack undergoes constructive and destructive interference effects, resulting in an increase in light transmission and a decrease in reflectance. When the reflection off of the screen is reduced, the image behind the touch panel is brighter and easier to read. Reflected light is also reduced, so the impact is a significant improvement in display contrast. The design of these coatings requires careful attention to the material properties and thickness of each component. All four surfaces-- the backside, two interior, and front can be AR treated, though any combination can also be selected in order to balance cost and performance. The fewer the surfaces treated, the lower the cost, but also the less reflection absorbed.

ANTI-GLARE COATING

Almost all touch screens put a silica (or other chemical) coating on the first surface to diffuse the reflective light and reduce the mirror effect. This is called an anti-glare coating, not to be confused with an anti-reflective coating and has a matte-like finish. Anti-glare coatings are relatively inexpensive and enhance the scratch resistance of the touch screen. However, anti-glare coatings diffuse the image and consequently reduce the sharpness of the display image, reducing visual clarity.

CIRCULAR POLARIZER

An alternative to AR coatings is the circular polarizer, which works to reduce surface reflections – displays with less than 1% reflectance are possible, increasing contrast ratios by up to 10x. An article by Geoff Walker, does an excellent job of exploring the sunlight readability in touch screens and compares AR with circular polarizers - http://www.veritasetvisus.com/VVTP-8,%20Walker.pdf.

CONTRAST ENHANCEMENT

A wide variety of color filters can be used in mil/aero displays to improve color contrast, brightness and overall image quality. For example, radar scopes fitted with touch screens have used a specific colors filter to adjust the apparent persistence of the phosphors. Some airline cockpits use LED displays, for which a neutral gray can enhance the ability to read the display. Night vision systems can make use of filters incorporated into the touch screen to block the NIR signature of the display.

LCD & LED BACKLIGHTING

LCD and LED backlights are integrated behind the display and are used in direct sunlight readable displays. Boosting light output by 200-300%, backlights are a maximize display brightness and contrast without adding a lot of extra heat or power draw to the display.

PRIVACY FILTERS

Privacy filters guard the security of on screen data and stop off-axis viewing of the display by blocking the light on either side, blacking out the screen to any viewing angle greater than 30 degrees so the image cannot be read. Manufactured by creating chemical louvers that let the light come straight through, this film allows only those placed directly in front of the filter to see the screen clearly. Privacy filters are often found in ATM-type applications, but can also be used in military-type settings to protect sensitive or classified information.

DBEF FILTERS

Display Brightness Enhancement Films are micro prisms, formed onto a sheet, which collect and focus the display backlight into bright spots. This filter makes a display appear brighter than the rating of the backlight.

OTHER ENHANCEMENTS

The enhancements below are solutions that do not fall into the EMI or optical categories, but play a vital role in the environmental performance of mil/aero displays.

FLAME RETARDANT

One of the main requirements of the aerospace market is the FAR 25.853 vertical burn, which is when a cross section of a touch screen is exposed to flame and must self-extinguish within 12 seconds or 60 seconds depending on its diagonal length. One of the main issues of concern is that the typical materials used in standard touch panes, tend to "wick," or continue to burn once ignited. The base material structures that Touch International can implement within a custom design have been formulated to pass the 12 and 60 second vertical burn test dictated by the FAA without deleterious effects to the light transmission rate.

TRANSPARENT LCD HEATERS

Transparent heaters are often found in rugged displays in extreme environments, and work to expand the operating temperatures of flat panel displays and backlights. Improving the display performance, especially at low operating temperatures, transparent LCD heaters allow operational temperatures to be reduced to -50º C for LCDs not previously rated to go that cold. Transparent heaters are optically clear (ITO), which allows them to be easily combined with other coatings and filters.

INFRARED FILTERS & HOT MIRRORS

While transparent LCD heaters work to keep a display warm in extremely cold temperatures, infrared (IR) filters and hot mirrors do just the opposite, working to reduce display heat and reject solar energy. These enhancements work to protect displays from damage caused by extreme atmospheric conditions, and prevent LCD clearing or blackout. IR filters reject up to 60% of solar energy, and all-glass hot mirrors reject 90% of solar energy.

OPTICAL BONDING

Optical or Direct Bonding is the process of fastening two or more optical elements together using a transparent liquid adhesive that has an index matched refractive index. Selecting the adhesive that corresponds to the display's index of refraction and overlay allows Optical Bonding to eliminate all air gaps, reducing the amount of the internal reflective surfaces and improving optical performance. This process also ruggedizes the display, making it more durable and able to resist higher amounts of shock, vibration, and moisture. While many rugged displays employ the use of optical bonding, it is especially important in mil/aero applications.

Benefits of Optical Bonding:

- *Prevents Condensation*
- *Improves Viewability up to 400%*
- *Improves Impact Resistance by Over 300%*
- *Increased Ruggedization and Shock Resistance*
- *Eliminates Air Gaps, Allowing for Thinner, Lighter Designs*
- *Eliminates Parallax Issues and Reduced Internal Reflections*

VALUE-ADDED SOLUTIONS SUMMARY

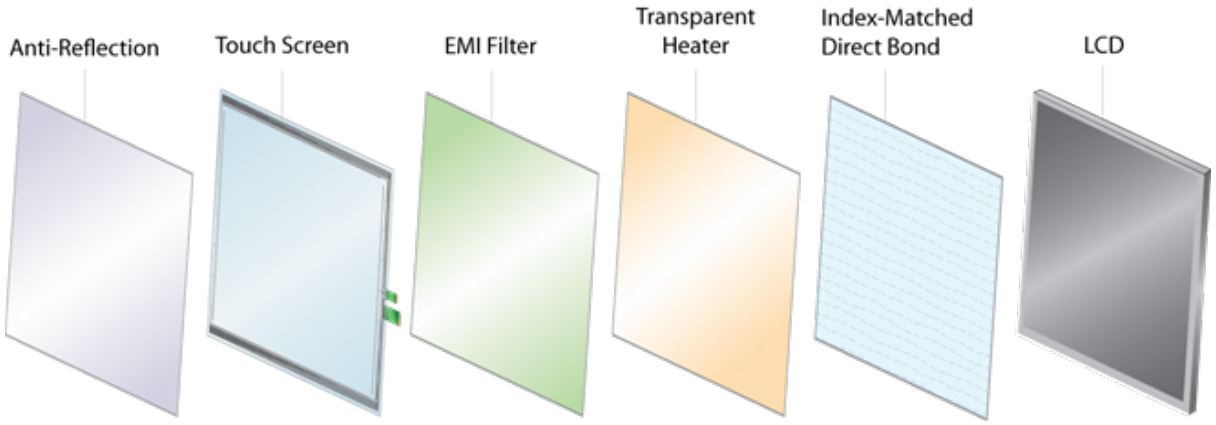
The combinations of enhancements that can be leveraged to optimize a touch screen or specialty dis-play are essentially limitless. By having a good understanding of what environment and challenges your mil/aero display will face, you will have a better understanding of not only what kind of touch panel to choose, but also the enhancements that might be needed to optimize the display performance.

PUTTING IT ALL TOGETHER

Below are two examples of touch panels with display enhancements which serve to illustrate what kind of combinations are often selected, and what issues are being addressed.

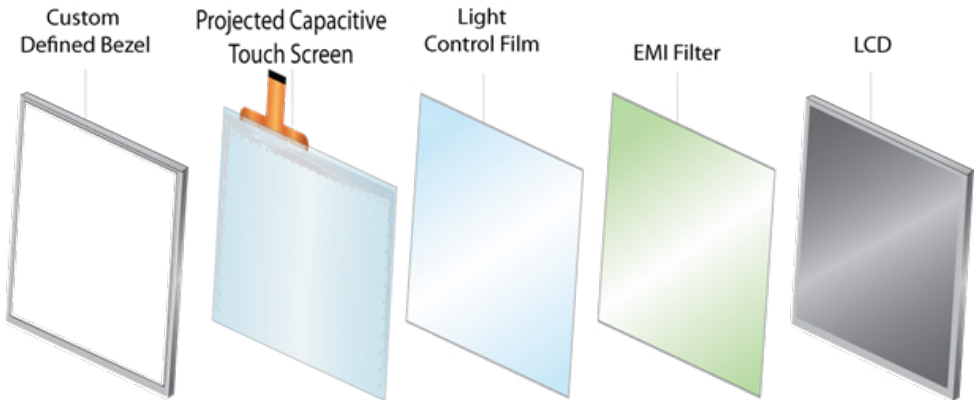
Military Application Requirements

- *Extreme Outdoor Environments*
- *Advanced Sunlight Readability*
- *Optimized Video & Light Images*
- *NVIS (Night Vision Imaging System) Compliant*



Aerospace Application Requirements

- *Low Toxicity*
- *Fire Retardant*
- *Low Emissions*
- *Fire Extinguishing*
- *High Temperature*
- *Head Impact Collision Compliant*
- *Optimized Viewing Angle*
- *Federal Aviation Regulations Compliant*
- *Outdoor Environments*



TOUCH TECHNOLOGY REFERENCE CHARTS

	Resistive	MAR	PCAP	SCAP	SAW	IR	Optical	DST	In/On Cell	APR
Power Consumption	Lowest	Low	Mid-Low	Middle	Mid-High	Highest	High	High	High	Middle
Preserve Image Quality	–	–	✓	✓	✓	✓	✓	✓	✓	✓
Cost	Lowest	Mid-Low	Middle	Low	Mid-High	High	High	Middle	High	Middle
Scratch Resistant	–	–	✓	–	–	✓	✓	✓	–	✓
Flexible	✓	✓	✓	–	–	–	–	–	–	–
Contoured (Curved Glass)	✓	✓	✓	✓	✓	–	–	–	–	–
Long Life	–	–	✓	–	–	✓	✓	✓	✓	✓

	Resistive	MAR	PCAP	SCAP	SAW	IR	Optical	DST	In/On Cell	APR
Pen Input	✓	✓	✓	–	–	✓	–	✓	–	✓
Single Touch	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dual Touch	✓	✓	✓	–	✓	✓	✓	✓ Emerging	✓	✓ Emerging
Multi-Touch (3 or more)	–	✓	✓	–	–	✓ Emerging	✓ Emerging	–	✓	–
Proximity Sensing	✓ Emerging	–	✓	✓	–	–	–	–	–	–
Z-Component	✓	✓	✓	–	–	–	–	–	–	–

	Resistive	MAR	PCAP	SCAP	SAW	IR	Optical	DST	In/On Cell	APR
2″ – 10″	✓	✓	✓	–	–	–	–	–	✓	✓
10″ – 17″	✓	✓	✓	✓	✓	✓	–	–	✓	✓
17″ – 32″	✓	–	✓	✓	✓	✓	✓	–	–	–
Large Format (32″ & Up)	–	–	✓ Emerging	✓	✓	✓	✓	✓	–	✓

** Based on research done by Touch International, these categories represent the findings of our sales and engineering teams. We recognize that there may be variations within the technologies and the suppliers.