

# Concept for an Avionics Multi Touch Flight Deck

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## ABSTRACT

Touch screen technology has experienced significant improvements recently, evolving to several solutions that are rugged enough to be introduced into the cockpit. A practical setup has been worked out consisting of four large PFD/MFD screens and two Touch Screen Control Units (TSCU's) which are positioned at the location of the classic CDU in the cockpit. All display surfaces have multi-touch capability. Apart from serving as a technology demonstrator, the setup will be used as a scientific test bed.

The goal of this study is to identify the benefits and optimize the usage of multi-touch screens in a cockpit environment. The focus is on creating a more intuitive operation and increasing the situation awareness. To investigate and demonstrate this, dedicated touch screen gestures were implemented and specialized flight deck applications were developed that facilitate direct manipulation of the flight plan. The PFD application is augmented with a Synthetic Vision System and integrates the tunnel-in-the-sky concept. As all screens are interconnected, collaboration between them is possible thanks to the touch screen interface.

In addition, the setup will be used to investigate the general applicability of multi-touch screens in the cockpit. Aspects of the research will include the effects of the location of the screen in combination with accelerations and rotations due to aircraft movement on the accuracy of the touch screen operation in general and the applicability of multi-touch gestures in specific. This investigation will be performed in a later stadium.

This paper will present the basic ideas of the concept, clarify the setup and explain how the touch-enabled applications work. The benefits will be highlighted as well as the drawbacks and need for future development work.

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## INTRODUCTION

A first study (Mertens et al., 2012) and realization was done to replace the traditional CDU in the cockpit with a more versatile Touch Screen Control Unit (TSCU). A Direct Manipulation Interface (DMI) was developed to allow the pilots to interact directly on the screen supported by dedicated graphics. User tests and surveys performed with this TSCU indicated a high preference for the direct manipulation interface to interact and revise the flight plan. The overall positive feedback collected on this concept lead us to continue on this track of revolutionizing the cockpit with a fully touch-enabled glass cockpit. For this purpose, the standard Multi-Function Display (MFD) units of the flight deck are replaced by four large multi-touch capable display units of 15.4" diagonal size.

The goal of this study is to identify the benefits and optimize the usage of multi-touch screens in a cockpit environment. The potential benefits of replacing the conventional flight deck displays with multi-touch displays are the increased flexibility of the interface content and structure, more efficient use of the limited display real estate in a cockpit, and the reduction of physical actuators like switches to help reduce material cost and maintenance cost. Further, the multi-touch applications do not only enable a more intuitive human-machine interaction, but also pave the way to create new types of visualizations to increase the pilot's situation awareness.

In this paper, dedicated touch screen gestures were implemented and specialized flight deck applications were developed that facilitate direct manipulation of a flight plan. A practical setup has been created consisting of four large PFD/MFD screens and two Touch Screen Control Units



(TSCU's) which are positioned at the location of the classic CDU in the cockpit. All display surfaces have multi-touch capability. The applications show a Primary Flight Display (PFD) augmented with a Synthetic Vision System and integrate the tunnel-in-the-sky concept. The Navigation Display (ND) as well as the two TSCUs show a plan view on the terrain, flight route, and navigation beacons and both allow the flight crew to revise the flight route while flying. As all screens are interconnected, collaboration between them is made possible thanks to the touch screen interface.

Apart from serving as a technology demonstrator, the setup will be used as a scientific test bed by integrating it into the SIMONA research simulator of the TU Delft. Aspects of the research will include the effects of the location of the screen in combination with accelerations and rotations due to aircraft movement on the accuracy of the touch screen operation in general and the applicability of multi-touch gestures in aircraft operations.

## OUR VISION

Direct manipulation of object by using hands and fingers is a natural and intuitive way humans interact with their natural environment. In modern work environments, such as a flight deck, humans need to interact with the environment through displays and often difficult to use human-machine interfaces. The main issue of this way of interaction is that it creates a semantic and cognitive distance between the *means*, that is, the control inceptors (e.g., CDU), and the *ends*, that is, objects under control (e.g., flight plan). A way to decrease this semantic distance is by employing touch screen technology to facilitate direct manipulation concepts.

A major challenge is to define the improved Human Machine Interface (HMI) which takes advantage of this new possibility. In this research some first, however still limited, operations are realized for the MFD units of the cockpit. The goal is to study their effect on the efficiency to operate them in a cockpit environment, and to analyse areas where effective usage of direct manipulation of symbols with touches can be created.

Some examples of these operations are:

- On the Primary Flight Display (PFD): change the Field Of View (FOV) of the Synthetic Vision System (SVS) as a function of the flight phase.
- On the Navigation Display (ND): to add or edit waypoints, and to zoom in and out.

In the future a new way of collaboration between pilot and co-pilot can be envisaged. With this new touch technology it is for instance possible for the co-pilot to point on an important area on his screen. This can be replicated on the screen in front of the pilot for his attention. Checklists can be presented on the screens and can be manipulated by touch inputs, enabling both pilot and co-pilot to work on the same checklist while this is presented in front of each on their individual display.

Other future possibilities are to highlight the taxi route by simply dragging over it with your finger, making clear for the crew where to steer to.

Navigation functionality could be coupled with charts eliminating the need to look in separate documents of files for relevant chart information for the current context of the cockpit.

It is our belief that at least some of the current state-of-the-art touch screen technologies have reached (or can be enhanced to) a sufficiently high maturity level to enable their introduction into the cockpit.

## THE SETUP

The full setup consists of:

- Four large screen multi-touch display units which are positioned at the MFD position in the cockpit.
- Two TSCU units at the position of the traditional CDUs
- Three personal computers (PC) serve as image generators and read out the touch sensors.

This setup is schematically depicted in [Figure 1](#).

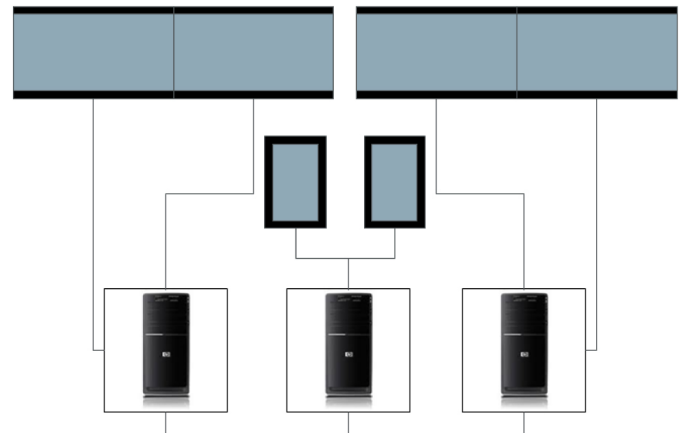


**Figure 1. System setup.**

This setup creates an experimental flight deck that is fully touch enabled. The PCs are synchronized with each other to make sure that the scenes presented on the displays are coherent with each other.

## DISPLAY & TOUCH TECHNOLOGY

### Technology selection

These days, aircraft information is in most cases presented to the pilots by means of electronic displays, hereby replacing the electromechanical instruments from the past. To this end, existing cockpits have been upgraded to LCD-based displays, and more recent aircraft platforms were designed from the start around -typically- 6 inch by 8 inch portrait displays arranged side-by-side in the flight deck. The introduction of these electronic displays allowed to present more information

in a more organized and consistent way. At the same time, interaction devices, such as joysticks and cursor control devices, made their appearance to allow direct interaction between the pilots and the aircraft systems.

Still, the aircraft complexity has continuously increased since then and additional information sources (such as sensors, cameras) have become available. The latest developments for new aircraft platforms, such as Airbus A350 and Boeing 787, make clear that there is an evolution towards less but larger displays having a size in the range of about 12 to 17 inch diagonal. This increase in dimensions is driven by the wish to improve the pilots' access to aircraft information and to allow for an optimization of data presentation.

Therefore, for this setup, 15.4 inch LCDs were selected with an aspect ratio of 16 by 10 and a resolution of 1680 by 1050 (WSXGA+). Both size and resolution were chosen carefully, in order to develop a display with an active area matching closely the total display area of two 10.4 inch (6 by 8) displays. Similarly, the pixel density is very similar to a 10.4 inch display with 1024 by 768 (XGA) resolution.

In analogy with the TSCU display developed previously [1], the LCD was enhanced with a projected capacitive touch (PCT) sensor to allow touch interaction with the PFD/MFD applications shown on the large-area displays. While PCT technology was initially limited to small sizes, touch screen manufacturers have successfully managed to improve the touch sensor design and controller sensitivity to make the technology feasible for larger sizes. PCT touch screens have now been demonstrated at sizes up to 32 inch diagonal [2]. Compared to other touch technologies, PCT technology supports true multi-touch and high resolution touch detection capability.

The operation principle of PCT technology is based on the disturbance of an electrostatic field above the display, when a finger (or any other conductive object) comes into close proximity with the surface. This field is generated by a current signal flowing through an X-Y matrix of conductive (ITO) traces on the touch sensor. As the conductive grid is in most cases protected by a top cover glass, it becomes possible to realize a highly durable touch screen solution. At the same time however, the presence of a touch sensor overlay creates additional challenges to make the display sunlight readable, and the potential visibility of the conductive traces may disturb the image quality even further. In addition, because of the nature of the technology, the compatibility with the typical EMI/EMC requirements in avionics is a concern and remains to be proven. As a consequence, off-the-shelf PCT touch sensor solutions will typically not be suitable for avionics display applications.

In the following, the assembly of our large-area multi-touch enabled display will be discussed.

### Display assembly

The integration of a PCT touch sensor into the LCD panel assembly results in additional layers in front of the LCD

glass. As every interface between materials with different refractive index adds to the total display reflectance, a lot of effort was invested into optimizing the design of all aspects of the LCD panel assembly. The final configuration is shown in [Figure 2](#) and consists of the following components:

- A front cover glass with broadband anti-reflection (AR) coating on the front surface. An anti-smudge top coating was added to protect the AR coating against permanent damage from the penetration of skin oils from frequent touch interaction.
- The PCT touch sensor glass with index-matched conductive ITO traces. As display size increases, the conductivity of the ITO traces, hence the layer thickness, needs to follow, hereby complicating the sensor optimization even further.
- An EMI/heater glass with index-matched ITO coating. This coating helps to suppress the electromagnetic noise generated by the LCD, which could potentially cause malfunctioning of the PCT touch screen.
- The 15.4 inch WSXGA+ LCD.

All components in the LCD panel assembly were optically bonded to further minimize display reflectance and to create a highly robust package. [Figure 2](#) also provides estimations for the reflectance contributions of each interface.

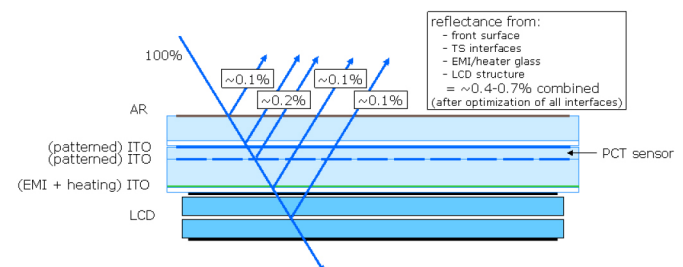


**Figure 2. LCD panel assembly configuration.**

The display assembly was completed with a custom-developed LED backlight system. The optical stack was designed to achieve a wide angular luminance distribution, to answer the requirements for cross-cockpit viewing.

### Sunlight readability

Sunlight readability is primarily decided by the reflectivity of the display. When using an off-the shelf PCT sensor solution, reflectance was measured to be as high as 2.5% specular, at 30 degrees angle-of-incidence (AOI). As this high reflectivity would make the display virtually unusable in the bright illumination environments commonly experienced in avionics, an enhanced touch sensor solution was developed. The resulting specular reflectance values are shown in [Figure 3](#).