

Touchscreen Display Enhancements for Flight Deck Applications

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ABSTRACT

Touchscreen displays are of growing interest to the aerospace community and are having a significant impact on how pilots interact with avionics. With the right hardware construction and software algorithm, a touchscreen display can manage and present information and controls to the pilot in an intuitive manner. This paper describes a hardware touchscreen rationale, primarily focusing on the lighting performance of a touchscreen display modified for flight deck applications. Specifically, we describe a durable glass-on-film-on-glass resistive touchscreen display with improved high ambient contrast ratio (HACR) properties and a low friction, lipophobic textured front-surface that disrupts the distinctiveness of reflective images.

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INTRODUCTION

Military and civil aviation increasingly rely on software controlled electronic systems to bring new functionality for improved performance and safety, reduced maintenance cost, and enhanced passenger comfort. In the past, electronic systems have been installed using a federated point-to-point or function-to-computer architecture [1]. This approach encapsulates the system function, data management, and display to a single control system. Although this type of system architecture is ideal for fault containment, it is an inefficient and even a profligate structure, particularly given the increasing number of electronic systems.

Hosting this increasing number of software-controlled electronic systems presents a challenge. As a fully encapsulated federated system, each electronic device has dedicated line-replaceable unit (LRU) and wiring. Maintenance, upgrade/improvements, and fuel consumption (due to the excess weight) have a high financial impact in operating an aircraft. Modern avionic architecture, built on a network-centric structure called integrated modular avionics (IMA), addresses many of these challenges [2]. This structure moves data to and from unrelated electronic systems onto a common data network. The IMA structure ultimately reduces weight and maintenance costs while also enabling rapid software/hardware upgrades [3].

IMA is also influencing the human-machine interface requirements in the flight deck. The information generated from each of the electronic systems may now be presented on

a limited number of displays. In years past, the function of the display was to present information as selected by activating a button on a surrounding bezel. Today, given the plethora of electronic systems, the display now serves three functions; (1) present data content, (2) allows content selection, and (3) enables control over various electronic systems. With this increased demand on the display, information needs to be managed in such a way as to minimize the pilot's cognitive stress level. A display with a clutter-free reconfigurable layout allows the pilot to access information and controls with the appropriate hierarchy.

Although not new to the consumer market, touchscreen displays have only recently started to have an impact on a pilot's interaction with avionics. This delayed entry is largely based on the challenging requirements of displays used in flight deck applications. Adding touchscreen functionality would seemingly compromise the optical performance of the display; particularly when viewed under high ambient lighting conditions. Yet given the right hardware construction and software algorithm, a touchscreen display can be fully sunlight readable and present information and controls to the pilot in an intuitive manner. This white paper reviews touch sensor technologies, contrasts three technologies that have been incorporated into aviation platforms, and describes a touchscreen display design rationale.

TOUCHSCREEN DISPLAY TECHNOLOGIES

The latest Federal Aviation Administration (FAA) Advisory Circular titled *Controls for Flight Deck Systems* provides an important precaution to companies that are developing touchscreen interfaces for flight deck displays (FDD) - the “*specific technology affects performance and failure, and is therefore important to consider*” [4]. This precaution is given in recognition that a myriad of different touch sensor technologies have been developed for displays [5]. Thus far, all of the traditional sensor technologies have limitations that restrict their use for avionics. For example, many lack the tactile properties important to prevent accidental actuation. Others degrade the optical performance of the display, compromising the contrast and sunlight readability properties. Even so, certain touchscreen technologies can be altered to meet flight deck specific needs.

At present, there are three different types of touchscreen technologies used within the flight deck; capacitive, infrared, and resistive. Each of these technologies offers some application specific advantage. However, an advantage for one application can be a strong disadvantage for another, particularly within a flight deck. Understanding the application is paramount in selecting the right technology.

AMLCDs are based on mature technology with properties that can be well suited for flight deck applications. The FAA's publication, *Human Factors Criteria for Displays*, has a very comprehensive list of requirements intended to insure that a display's content is viewable under all conditions for civil aircraft applications [6]. Other specifications provide similar criteria for displays from a military perspective [7], [8]. These documents are intended to guide the manufacturer to make displays which are easily read when viewed under both bright sunlight as well as moonless night conditions. Figure 1 shows examples of displays that meet all the visual performance standards necessary for flight deck applications; including HACR, luminance, color, uniformity, and wide dimming ratio, all over application specific viewing angles.



Figure 1. Korrry Displays, manufactured by Esterline Control Systems.

In contrast, touchscreen specifications for flight deck applications are still evolving, and the *Computer-Human*

Interaction (CHI) requirements are not fully established [6]. Even so, there are certain application specific requirements that are understood through experience.

For flight deck touchscreen displays, the pilot is directly interacting with the display to select and control data content, monitor functions, actuate switching elements, and manage information concerning the real-time operation of the aircraft. For such applications, a touchscreen display must, as a minimum, have the following features:

1. The system must minimize the possibility of accidental actuation under all conditions (including turbulence).
2. The display content must be viewable under high ambient lighting conditions.
3. The interface must be easy to use with an intuitive graphic-user-interface (GUI).
4. The system must be reliable.
5. The interface must have application appropriate touch resolution.
6. The interface must be able to sense a finger, a gloved finger, and a stylus.
7. The touch surface must be durable and not prone to scratches during use or cleaning
8. The touch surface must have minimal adhesion to finger-prints and must be easy to clean.
9. The touch surface must have a smooth, low stiction expression for mobile gestures such as pinching, dragging and swiping.

TOUCHSCREEN RATIONALE

Table 1 compares the three sensor technologies used in flight deck applications relative to some of the required features described in the previous section. Impeding accidental actuation is perhaps the most critical feature for touchscreen controllers. Both the hardware and the software can be designed with this in mind. Certain software algorithms can be applied regardless of hardware selection. However, hardware that requires physical touch and applied force minimizes accidental actuation and therefore has a distinct advantage on the flight deck. A resistive touchscreen inherently requires an applied force to actuate and therefore is advantageous. Both capacitive and infrared technologies need substantial alterations to meet this requirement; left unmodified these technologies are prone to accidental actuation.

On the other hand, it is commonly believed that resistive touchscreens degrade the optical performance of a display to the extent that the content cannot be read when viewed with sun light reflecting off of the front surface. While sunlight readability is a problem for commercial resistive touchscreens, the system can be designed to improve the