Projection Displays in Avionics

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ABSTRACT

Avionics represents a specialized area of display applications. A possible future development in this field is a single display cockpit environment with touch input capabilities. Such a seamless, tiled cockpit display based on several short throw wide angle projectors is being developed in the European Project ODICIS. The current results are discussed in this contribution.

1. INTRODUCTION

In avionics applications, the use of displays is abundant. There has been an evolution from a large number of separate gauges, over a larger number of small (CRT-type) screens to the limited number of LCD displays that are to be found in the modern aircraft cockpit (see figure 1).

The ongoing trends for the use of displays in aircrafts can be summarized as follows:

- A rationalization of the needed equipment. This is achieved on the one hand by reducing the number of dedicated input and output media and on the other hand by optimizing the usage of the available ones.
- An improvement of the system availability and fault tolerance.
- An increase of the size of the displays and a further reduction of their number.
- The cockpit is treated as an integrated workspace, with a trend towards a "paperless" cockpit (Figure 2).

Figure 1. Modern cockpit of an Airbus A320 aircraft, featuring 6 larger size LCD displays.

Figure 2. Cockpit of an Airbus A380 aircraft. The cockpit serves as an integrated workspace.

A very promising new concept for a future cockpit that combines these trends and needs into a new paradigm is the concept of a single display interactive cockpit.

The advantages of this single cockpit display are found in different domains. From the technological side, it would become possible to have a common architecture that could be easily adapted to each airplane type. Only the physical dimensions of the screen would have to be adapted, the underlying engine would remain the same. This is sharply contrasted with the classical approach, where each display and gauge has to be refitted.

From the viewpoint of the man-machine interface, the elimination of the physical barriers between the different screens is also important, as it gives more freedom in the concept of the human-machine interface. It would be possible to have a reconfigurable dashboard, where important elements can be placed in prominent view at will, as the situation requires. A combination with a display-wide touchscreen input device provides a complete, self-contained means of controlling the cockpit.

2. SINGLE DISPLAY COCKPIT

The European project ODICIS aims at developing and providing the technological means for such a “One Display Interactive Cockpit Solution”. Figure 3 shows how such a solution may look like.

The main targeted requirements for the display system in the project are:

- A curved surface, non-standard form factor, large screen display with high information content density and superior image quality compared to today’s display cockpit.
- A display that meets avionics specifications in term of safety, ergonomics and cockpit environment.
- A display that offers better features in terms of flexibility for showing user-defined cockpit configurations and user interactivity.

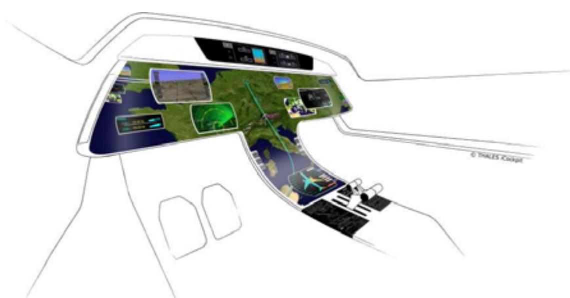

Figure 3. Artist’s view of a single display interactive cockpit concept.

A crucial task is the selection of an appropriate technology to create the single display. Important factors are the compliance with the numerous avionics safety regulations and the need for short term availability, i.e. mature technologies are required.

3. TECHNOLOGY SELECTION

3.1 LCD Panels

State of the art LCDs are of course a first obvious candidate, as several current avionics cockpits already use rugged LCD panels. LED backlight is now ubiquitous as illumination source, providing enough brightness to display bright images with excellent uniformity. High contrast ratio is achieved by automatic dimming of the backlight and viewing angle can be controlled to obtain the desired characteristic by applying add-on films.

The main problem is the need for a very large, curved display with an uncommon form-factor. This is far outside the mainstream LCD technology and would thus need costly development for a very limited market.

Tiling several LCD modules is in theory another option to adapt to the special form requirements of the application. Unfortunately, a gap of 1 mm between each image is about the lowest value reachable between adjacent panels, so composing a real seamless display is impossible. LCD panels thus seem not adapted to the aims of the project.

3.2 Classic emissive displays

A second option are emissive displays, which comprise plasma display panels (PDP), surface-conduction electron-emitter displays (SED) and field emission displays (FED). By their nature these displays perform very well in terms of readability and viewing angle. Otherwise, these panels are very similar to LCD panels. All prohibitive constraints on the ability for special shapes and seamlessness are as true for emissive displays as they are for LCD panels. Thus, emissive flat panels are not an option either.

3.3 OLED displays

OLED displays are of course a very promising candidate. They consist of very thin panels which would allow a weight and space saving. Power consumption is relatively low and the possibility for flexible displays has been demonstrated, although a lot of limitations are still present.

The negative points are then mainly related to the maturity of the technology: the overall maturity of the technology is too low for avionics use, brightness is still not high enough and there is of course still a lifetime issue. This excludes OLED from consideration.

3.4 Projection

Finally, projection technology is to be considered. This technology is very versatile and adaptable. Resolution can be as desired without size constraints. A curved image plane should be no problem since only the screen has to be physically altered; keystone adjustment can be done electronically. Big, truly seamless tiling is possible using multiple projectors and has been demonstrated in simulation and control environments.

It is a very mature technology and can be used with different image sources. Projection was thus chosen as the technology platform for the single display cockpit.

4. REALISATIONS

4.1 Core optics

For the image source, LCOS microdisplays have been chosen because of their ruggedness, the large choice of resolutions and the availability of multiple manufacturers.

The strong vibrations in an avionics environment can affect moving parts such as color wheels. To eliminate the risk for any ensuing color artifacts and meanwhile ensure highest reliability, a three channel color system is used. These color recombination optics have already undergone a considerable amount of development and are readily available with the matching LCOS panels already mounted. Consequently, an existing commercial core with high-resolution panels was selected to be used as building block for the projector (see figure 4).

Figure 4. A commercial color recombination unit with LCOS panels.

Because arc lamps cannot be used in an avionics environment, both due to explosion and fire risk and reliability, a custom LED based illumination system has been designed. This had to take into account the high demands on brightness, imposed by the screen legibility requirement in direct sunlight. Around 400 cd / m^2 are needed to provide an acceptable level of brightness under all circumstances. This is feasible with today's state of the art projection LEDs provided a careful light management is foreseen. Reliability over a long lifetime is also a key factor for a crucial component as a cockpit display. The LED's main failure and degradation mechanism is related to junction temperature excursions, so an adequate cooling system that is by itself very robust has been developed.

One of the biggest challenges, next to the safety constraints, is the very limited space available in the cockpit for the projection engines. Any newly developed system should not take up more space than the currently used rugged LCD display units. This poses serious demands on the projection system, as the throw distance is only about 25 cm. Hence, a dedicated short throw ultra wide angle projection lens was designed to accommodate for this short range projection while keeping a small footprint (Figure 5).

4.2 Cockpit integration

The curviness of the screen and the special form factor (i.e. the T-shape shown in figure 3) are dealt with by splitting up the display area in five projection areas, each with their own projector unit. The individual projection images are then tiled using blending techniques to form one seamless display (Figure 6).

Touch screen input is provided by a proprietary optical design that does not alter the readability of the display.

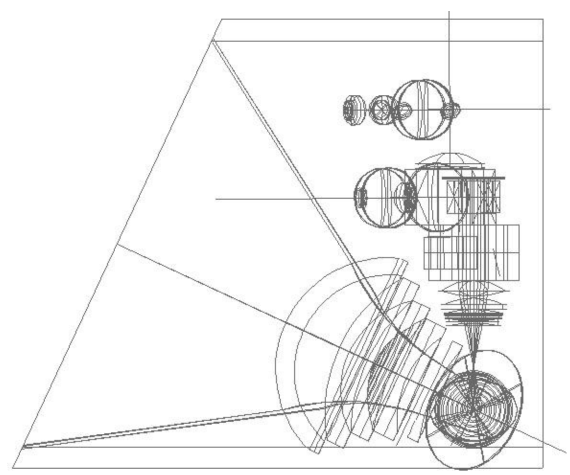

Figure 5. Design of the short throw ultra wide angle projector.

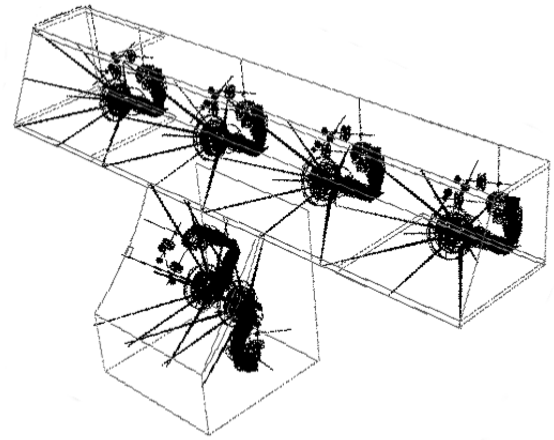

Figure 6. Arrangement of five wide angle projectors that make up the single display in the cockpit

5. CONCLUSION

A new concept for a cockpit display has been proposed in the research project ODICIS. It features a seamless, single display realized by projection technology. In the current status of the project, all elements of the single display have been designed and the prototype is being built. Figure 7 gives an impression of a possible cockpit layout with the single display.

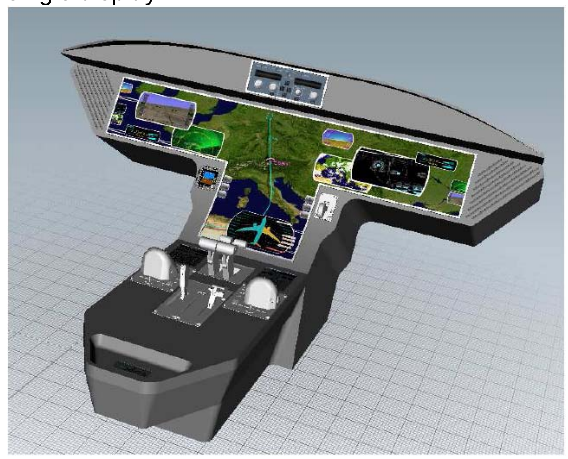

Figure 7. Artist impression of the single panel display integrated in the cockpit.