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Discrete Information Object Analysis of Primary Flight Display Clutter

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Introduction

Glass cockpits, digital display systems used to display critical flight information and status of aircraft systems, are ubiquitous in modern aircraft and continually are improving in capabilities. However, there comes a point where the data displayed, despite being designed to increase pilot performance and safety, serve as a detriment to situational awareness.

Traditional flight deck designs made use of several instruments, distributed from the center of the instrument panel in a somewhat relative order of importance, forcing pilots to develop a scan pattern to seek requisite information. Glass cockpit systems display much of that same information in a smaller area, minimizing scanning but increasing complexity.

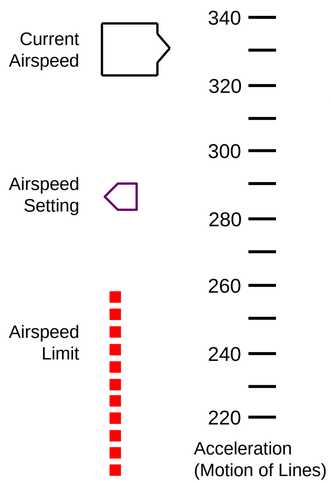
Both the manner in which the data is presented visually and the type and amount of information can serve as distractors from the task of flying an aircraft. This effect is termed *clutter,* and is defined as the "unintended effect of imagery display that obscures or confuses other information, or that may not be relevant to the task at hand," (Kaber et al., 2008, p. 1008). Pilot perceptions of clutter vary with flight experience, introducing unique considerations in the flight training environment, given the experience difference between instructors and students.

Methodology

The author reviewed literature on types and effects of clutter in aircraft displays. The purpose of the review was to assess extant research on display clutter and to develop recommendations to incorporate context into the model.

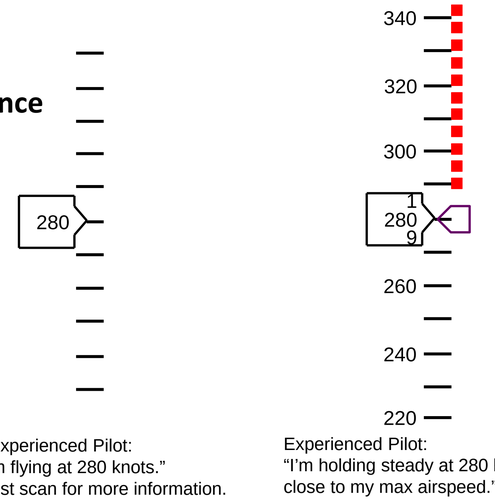
The literature review began with a database search for combinations of the terms "aviation," "aircraft," "clutter," "perception," and "gestalt." The researcher used subjective judgment to emphasize sources from scholarly journals describing clutter in aircraft with digital flight displays.

Separate visual elements with related information



Perceived a single object from context and experience

Experienced pilots perceive more elements simultaneously



Inexperienced Pilot:
"I'm flying at 280 knots."
Must scan for more information.

Experienced Pilot:
"I'm holding steady at 280 knots, close to my max airspeed."

Discrete Information Objects

A discrete information object is hereby defined as a unique area of a visual display depicting one or more data sources that provide related information, its boundaries defined by the information contained within. It is the gestalt of the visual elements and information sources of a particular region, perceived by the user as a single information source. Discrete information objects can be used as a construct to assess display clutter, bridging the definitions of visual and information clutter, and incorporating usage context into the model. They are composed of one or more objects, but perceived as a single source of information.

Pilots seek specific areas of the display for knowledge required for specific flight tasks. Where in traditional instrument panels this was accomplished through visual scanning of several individual instruments, it is now accomplished through visually scanning several overlapping areas of the display. Each individual visual element, however, is not scanned; instead an area large enough to gather related information in close proximity is scanned, with attention divided as needed to process relevant data and information sources within that area.

Visual density and information density have been extensively studied in relation to display clutter. While pilot performance can be affected by perceptions of clutter, research indicates clutter has a large effect on pilot workload, a cognitive process. Analyzing clutter on a display as a collection of discrete information objects, as perceived by the pilot, may better link analysis with context and pilot perceptual processes.

This concept also allows for simultaneous analysis of visual and informational elements as useful elements of a display. Eye tracking or other visual scan measurements may prove insightful as means to measure what elements of a display are perceived as information objects. Fixation on a portion of the display, along with satisfactory pilot performance, may indicate a low density of information objects and low perception of clutter. Conversely, increased scanning may indicate the presence of multiple information objects and a correspondingly high perception of clutter.

Training Implications

The training environment introduces a possible disparity in crew perceptions of flight displays given the experience gap between student and instructor. Kaufmann and Kaber (2010) found pilots who can better "divide their attention across a display are less prone to experience clutter in the display than those who must switch attention from one area of the display to another in order to gather needed information" (p. 74). Pilots also vary in the size of the display area in which they can divide their attention.

When coupled with the concept of clutter, it may be that experienced pilots are perceiving more of the display as a single source of information, rather than seeking data from multiple sources on the PFD.

An analysis of the information objects used by flight students and instructors may provide greater insight into how and when different portions of a flight display are used by each. Furthermore, it may indicate portions of the display perceived differently by pilots as useful or cluttered. Awareness of these factors can lead to development of better flight displays, displays with different software de-clutter options, improved training techniques, or alternate instrument scanning techniques.

Future Research

Future research can analyze perceived clutter in specific displays and scenarios and aid in designing new means to present information to pilots.

Despite subjectivity in individual perception, information objects can be modeled. A hierarchical tree may aid designers and researchers in determining which sources may be perceived by users as a whole, and at what level. Elements will require some form of weight to account for proximity and context, as items not appearing in physical or temporal proximity are unlikely to be perceived by a pilot as a whole.

References available upon request