An Approach for Designing Flight Symbology

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ABSTRACT

The goals of this effort are to identify features of navigation symbology that are problematic when presented on electronic displays and to develop a method to design and evaluate good symbology that takes into account the different platforms on which it will be displayed. Background findings and a proposed experiment to explore some of the higher-level issues related to the design of effective symbology are described.

BACKGROUND

An increasing number of electronic displays are showing navigational information, i.e., information shown on aeronautical charts that assists the pilot in determining the aircraft's position. The display may be an in-flight moving map display on a Flight Management System (FMS), an electronic chart, an airport surface moving map display, or a moving map display on a Global Positioning System (GPS) unit. The design of navigation symbology is especially complex due to this wide range of display technology.

Research examining how a symbol should be *designed* is relatively new in the aviation domain where symbols are usually created by manufacturers without formal human factors testing. The goals of this effort are to identify features of navigation symbology that are problematic when presented on electronic displays and to develop a method to design and evaluate good symbology that takes into account the different platforms on which it will be displayed.

In order to achieve these goals, we needed to understand what display technologies are in use and determine what symbology standards exist. We documented a list of issues related to the design of symbols for electronic moving maps and proposed experiments to address higher-level issues related to the design of effective symbology. Results of the research are expected to be of use to industry and the aviation authorities, e.g., Federal Aviation Administration (FAA), that are setting symbology standards. This paper reviews the progress and plans made to date on this effort.

DISPLAY TECHNOLOGIES

How a symbol looks on a display will vary depending on the physical qualities of the display, so our first step was to determine the different displays in use. Commercially available systems that included a moving map or chart display were identified through a web search and published product literature. These systems were primarily used by general aviation (GA) pilots. The results showed that from a symbology point of view, the biggest difference between GA low-end and high-end displays is resolution.

We were also interested in the display technologies used in air transport aircraft. Four display manufacturers were contacted and asked to provide specifications for what they considered to be their low-end and high-end displays. The results of this survey indicated that while display resolution was still important, it was not a limiting factor; in fact, the resolution of what was considered a low-end display for air transport aircraft was higher than the resolution for some high-end displays used in GA operations. Rather, the important issue for air transport displays is optimizing contrast, e.g., by increasing luminance or stroke width.

STANDARDS

There is currently no common standard across organizations and manufacturers regarding what symbols to show on electronic displays of navigation information. Standards for moving map displays are addressed by several organizations (e.g., International Civil Aviation Organization (ICAO) Annex 4 [2] and RTCA DO-257A [3]). The Society of Automotive Engineers (SAE) has developed an Aerospace Recommended Practice (ARP) for electronic aeronautical symbols [4]. However, informal discussions with manufacturers suggest that the SAE recommended symbols are not in widespread use. One reason is some of the symbols require a level of detail that is not possible on some displays. Another is that some of the recommended symbols are similar to copyrighted symbols; consequently, some manufacturers are wary about using them.

Symbols from eight different manufacturers were compared. The comparison highlighted the use of non-standard symbols and varying levels of detail in the symbols depending on the manufacturer. Thus, the potential for confusing and misleading symbology exists.

DESIGN ISSUES

The symbol design must be able to directly convey the information represented, without inhibiting or interfering with the interpretation of other symbols [4]. In order to determine whether symbols are designed appropriately and effectively for electronic displays, a list of research issues was compiled (see Yeh and Chandra [5] for a discussion). The issues can be summarized into four basic questions that can be used to measure the *usability* of a symbol:

- Is the symbol easy to find?
- Is the symbol distinctive from other symbols?
- Is the on-screen symbol size appropriate?
- Are rules for encoding symbol attributes intuitive so that they can be decoded quickly and accurately?

PROPOSED EXPERIMENT

We are currently pursuing studies to understand the higher-level issues related to the design of effective symbology. Our current goal is to determine the effects of complexity on symbol design and the extent to which users can interpret symbol meaning as symbols become more complex. Recently, the United States (US) submitted a proposal to ICAO to establish a charting hierarchy so that there is a consistent method for distinguishing between ground-based points and GPS/Area Navigation (RNAV) points for navigation purposes. The proposal also recommends a consistent way to modify symbols to distinguish between compulsory vs. on-request reporting and between fly-over vs. fly-by requirements [1]. Table 1 provides an example.

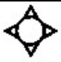
Symbol shape: Navigation equipment	**Fill** Unfilled = On-request	Filled = Compulsory
Triangle = Ground-based		
Waypoint = RNAV		

Table 1. Symbols defined by combining shape and fill.

As Table 1 shows, the *symbol shape* designates the navigation-equipment requirement. A triangle symbol identifies the location of fixes and intersections, defined by ground-based navigation aids, and the four-pointed waypoint star identifies the location of RNAV waypoints, defined by coordinates as points in space. The shape attribute is combined with fill to indicate whether the point is an on-request or compulsory reporting point. An unfilled triangle represents on-request reporting at a ground-based point, and a filled triangle represents compulsory reporting at a ground-based point. A third attribute (not shown above) is the presence or absence of a circle that surrounds the symbol. The circle differentiates between a fly-over requirement (circle) and a fly-by requirement (no circle).

The planned experiment will evaluate the usability of the rules in learning symbols' meanings. Participants will be shown a symbol and asked to identify it and indicate whether it represents a fly-by or fly-over requirement, whether it is compulsory or non-compulsory reporting, and whether it is a ground-based or RNAV point. Our dependent variables will be the response time needed to make the classification, the response accuracy, and a rating of the participants' confidence in the response. Considerations for the experiment design are discussed below.

Participants. Pilots' background and training will influence their familiarity with symbols. Participants may be from one of three groups: air transport pilots who fly in the continental US, air transport pilots who fly transatlantic flights and therefore have more experience with compulsory reporting, and GA pilots who fly in the continental US.

Symbols. Three symbols types (NAVAID, triangle, and waypoint) will serve as *base symbols*. Each symbol may be modified in two ways: *fill* to designate compulsory vs. on-request reporting, and *the presence or absence of a circle* to designate fly-over vs. fly-by. Distractor symbols will also be shown to determine whether or not participants can apply the rules to other symbols and to determine whether new symbols created by the charting hierarchy will be confusable with symbols currently used by other chart providers.

Symbol Legend. The amount of instruction that participants are given about how the symbol rules are applied will influence their ability to infer the rules. The level of detail in a legend may vary from minimal to detailed. A minimal legend would provide one or two examples of the rule without explicit instruction, while a detailed legend would provide explicit, detailed description of the rules and many examples.

APPLICATIONS

The charting hierarchy illustrates a logical, consistent way to design symbols. The proposed study addresses whether pilots can understand and apply the charting hierarchy rules proposed by the US. The results of this experiment will provide input to the FAA on the usability of the proposed charting hierarchy. In addition, this research will support the efforts of the SAE G-10, Aerospace Behavioral Engineering Technology Committee, Electronic Charting Subcommittee in its upcoming effort to update ARP 5289 [4]. While the scope of this work addresses navigation symbology, the techniques used here are applicable for addressing the usability of other types of symbology.

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