Non-Traditional Displays for Mission Monitoring

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Introduction

Advances in automation capability and reliability have changed the role of humans from operating and controlling processes to simply monitoring them for anomalies. However, humans are traditionally bad monitors of highly reliable systems over time[1]. Thus, the human is assigned a task for which he is ill equipped. We believe that this has led to the dominance of human error in process control activities such as operating transportation systems (aircraft and trains), monitoring patient health in the medical industry, and controlling plant operations. Research has shown, though, that an automated monitor can assist humans in recognizing and dealing with failures[2,3]. One possible solution to this predicament is to use a polar-star display that will show deviations from normal states based on parameters that are most indicative of mission health.

Description

On commercial flight decks, monitoring aircraft state is an important function of the flight crew. However, it is often difficult for the crew to notice subtle changes in highly reliable and complex environments. Information is often spread throughout the flight deck and displayed in different formats, adding to the potential for missing a deviation. Unfortunately, such subtle deviations have contributed to a number of accidents (*e.g.*, the Air Florida accident[4]). We propose the use of polar-star displays to present aggregate systems information that not only alerts the crew to subtle deviations in mission state, but also gives them information useful in the diagnosis and recovery process. This paper describes research in determining the groupings and parameters to be used in the polar star displays.

Three groupings show promise. The aviate-navigate-communicate-systems grouping follows the traditional teachings and operations for flight (fly the aircraft first, then determine position and new course, then communicate information) and is further supported by other research[5-7]. Locus-of-control, a grouping found in previous research looking at the order of actions pilots perform during non-normal situations[6,7], refers to how much control the subject is able to exert over a task. The final grouping is an earth-plane-system reference system, which allows the operator to monitor aspects of the plane in the world, the plane itself, and particular aspects of the plane.

First, the parameters that pilots require to monitor aircraft status needed to be determined. This was accomplished through a web survey. Twenty-five pilots completed the survey that asked them to rate parameters available on the flightdeck[8] on whether they were needed for the completion of a safe flight, not required to complete a safe flight, or not needed for a safe flight. The rest of the survey asked the subjects to decide on the reference point for each piece of information. The reference points were earth, the information is best understood and described from an earth-based frame of reference; plane, the information is best understood from the aircraft's frame of reference; and system, the information is best understood within the context of a system. This survey and previous research determined the groupings of the required information in 3 reference systems: aviate-navigate-communicate-systems, locus-of-control, and earth-plane-systems.

Results

Results from the web-based survey indicated that there are 16 parameters that flight crews need to accomplish a safe flight (table 1). The survey also indicated the groupings for the earth-plane-systems based reference system (table 1). These same parameters were also organized into the other 2 groupings (table 1). Next, an experiment to determine if the polar-stars display aids in monitoring aircraft state and the appropriate groupings of the aircraft state information needed for best monitoring and preliminary diagnosis of aircraft state will be done.

Although this research was undertaken in the aviation domain, the methodology is applicable to any human monitored operation including nuclear plants. When monitoring large, complicated processes, it must first be determined what information the controller needs to perform his job safely. These parameters should then become the focus of the operator when monitoring plant operation. How this critical information should be grouped and displayed then needs to be determined. The grouping of the information is particular to the operation involved. In many instances, the operators already group the information in a manner that has been documented, such as aviate-navigate-communicate in the aviation domain. Other groupings may also be possible. In this case, an experiment designed to realistically test for the best information grouping must be done with the operators of the plant. As for how to display these critical monitoring parameters, we propose the use of polar-star displays.

References

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Table 1 – Parameters Needed and Groupings of Parameters

Earth-Plane-Systems	Aviate-Navigate-Systems	Locus-of-Control
Earth	**Aviate**	**Inner**
velocity	lift/weight	velocity
latitude	pitch	pitch
longitude	yaw	yaw
altitude	roll	roll
vertical velocity	thrust/drag	vertical velocity
		heading
Plane	**Navigate**	**Middle**
lift/weight	heading	lift/weight
pitch	altitude	altitude
heading	latitude	latitude
yaw	longitude	longitude
thrust/drag	vertical velocity	thrust/drag
roll	velocity	
System	**System**	**Outer**
pressurization	pressurization	pressurization
hydraulic	hydraulic	hydraulic
electrical	electrical	electrical
fuel	fuel	fuel
engine	engine	engine