Applying User-Centered Design Methodology to Portable Lightweight GPS Receiver (PLGR) Interface

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Abstract: The current design of Portable Lightweight GPS Receivers (PLGR) seems to be difficult to use in stressful military situations. Its use has contributed to a number of friendly fire incidents in military applications. This study consists of a user-centered evaluation of the existing PLGR interface design. It includes a user requirements analysis, a task analysis and a system data flow diagram. Through the application of these HCI tools, the proposed redesign is expected to improve screen layout, map display options, and grid coordinate display.

1. INTRODUCTION

"Once I made that number mistake [reading the wrong grid coordinate], for everybody on that battlefield those vehicles became the enemy. … I read a wrong line of information and that convinced the ground commanders that that was them, that's the bad guys, take 'em out…. Then the call came in, 'friendly vehicles may have been hit'... [It was] horror." LTC (Ret.) Ralph Hales, 60 Minutes Interview, circa 1992.

In this instance, the user incorrectly interpreted a grid coordinate on a device similar to a Portable Lightweight GPS Receiver (PLGR), causing military actions against friendly forces. Human error has often been mentioned as the primary cause of this type of mishap (Snook, 1996). In this paper, we explain how our analysis, based on user-centered design methodology, might be used to explain design improvements and reduce human error for this type of system.

2. USER-CENTERED ANALYSIS

The PLGR is one of the most widely used GPS receivers in the military today. PLGRs are used by infantry and artillery units to plot precise positions for gun systems both in tracked and wheeled vehicles. PLGR is critical to providing real-time, precise position data for all combat elements to the battlefield information systems (http://army-gps.robins.af.mil/ue/plgr.htm). PLGR only receives information; it does not relay data nor emit any data sending signals. However, the information a soldier receives from the PLGR is used in various ways to help navigate in stationary or moving vehicles. We now present the components of our user-centered analysis and redesign.

2.1. User Profile: The primary users are the soldiers, with the task of identifying their location through the use of grid coordinates. The secondary users are the squad leaders who receive the grids, and the company commanders and unit level tactical planners who develop movement plans and operations. One of the key behavioral issues we must address with the redesign of the PLGR is the fact that soldiers often operate in highly stressful mental and physical environments and are often fatigued. Therefore, the system should provide information that is easy to understand in standard units of the Military Grid Reference System.

2.2. System Input/Output: The PLGR has three main sources of system input. These three sources include the user, the GPS satellite system, and other military devices. Figure 1 presents the current PLGR device interface formatted to show the data display groups. The user provides basic preference information such as refresh rates. Also the user has the capability to input waypoint information as well as detailed obstacle location and information. The GPS satellite system provides navigational information to the system. This system determines the location of the user and transmits this information to the PLGR. Waypoint information can be transferred between PLGR devices so a group can have synchronized waypoints. Finally, other military devices can be synchronized with the PLGR to provide GPS accurate time.

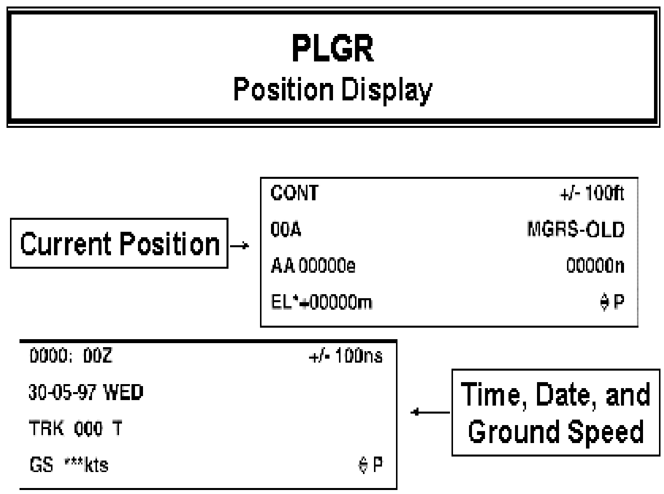

Figure 1: The current design of Position Display Screen for the PLGR, showing only the data groups.

The main, and only, output for the system is the navigation information. This information is based on the three inputs described above. The navigational information that is presented can be a grid coordinate, elevation, azimuth, and speed. Output also includes waypoint navigation information, such as distance and azimuth to next waypoint or obstacle information similar to the waypoint data. One of the most important outputs of the PLGR is relative location information. Soldiers should be able to see their location in relation to other pre-programmed locations on the battlefield. Locations that a soldier would want to be aware of include friendly headquarters, obstacles, nearest waypoints, and known enemy locations. The soldier should also be able to see his/her position on the ground relative to significant terrain features in the map area visible on the interface. It is critical to provide appropriate navigational tools in the interface to aid wayfinding in virtual space, including maps, landmarks, trails, and direction finding. These tools will display current position, current orientation (e.g., compass), guided (or unguided) movements in surrounding (Darken and Peterson, 2002).

2.3. Task Analysis: To begin the analysis, a series of analyses were performed for the major tasks soldiers must perform with the PLGR. Some of the critical tasks are: obtain navigational information, find out location (coordinates), find elevation, find speed, find azimuth, find locations of obstacles, enter locations of obstacles, and find distance from waypoint. Many of these task analyses were complicated and required up to 8 levels of interaction for task completion. In order to streamline this process, the new PLGR design would feature "Quick Keys" to immediately execute the tasks most often required of the device. In doing this, the HTA was decreased from 8 levels of interaction to 3. We present a Hierarchical Task Analysis for the tasks associated with obtaining general navigational information for the user using the redesigned "Quick Keys." This HTA depicts the task of finding grid coordinates, elevation, and speed for both moving and stationary users (see Figure 2).

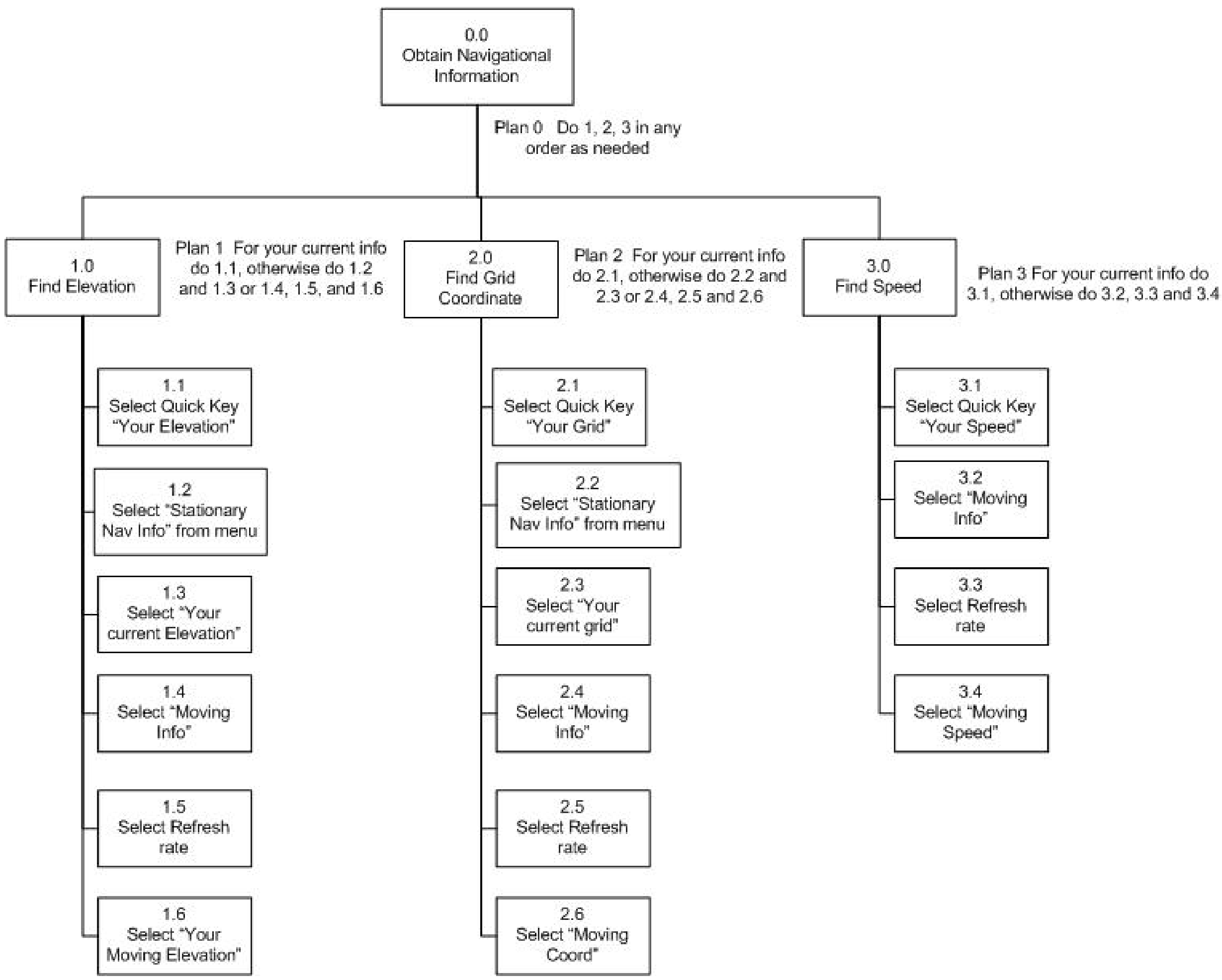

Figure 2: The HTA for tasks related to finding grid coordinates, elevation, and speed for both moving and stationary users.

We also modeled a State Transition Network (STN) to clearly picture how many transitions must occur before the user completes each specified task (see Figure 3 for an STN depiction of "Find Speed"). It is interesting to note that the nodes on the HTA become the arcs on the STN. The process of creating STN then shows us how to allocate a specific task to a certain interface attribute.

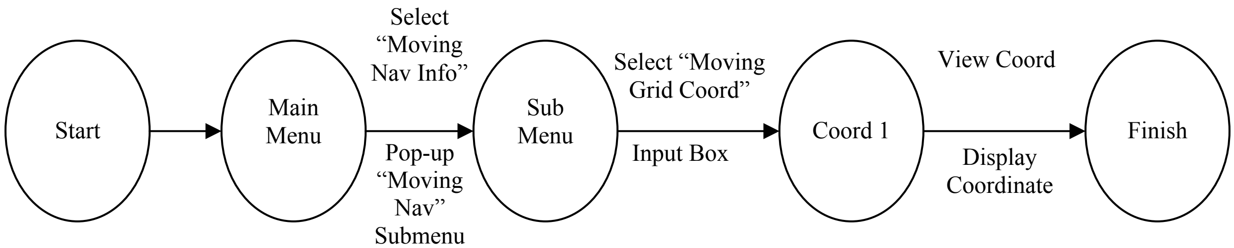

Figure 3: The STN for "Find Speed"

The STN and HTA analyses of the three tasks illustrated that the quick keys were an effective way to allow the soldiers to access the information they use most often. The quick keys only have the single function that is described on the key and only require a single press to provide the soldier with the critical information he needs. This interaction does not create a large cognitive load to access the information. There is clear confirmation that the soldier is reading the correct information on the display. Since the function keys have a single function, there is no chance that the keys will be accidentally pushed for a different purpose. And the fact that the description of the task is written on the key itself requires much less emphasis on short-term and long-term memory, with little potential for error.

3. INTERFACE REDESIGN

Two interaction styles were considered for our redesign: menu and Q/A. The nature of the task involved lends itself to a hierarchical design and menus seem to be the most efficient way of representing this style of interaction. Q/A, on the other hand, is too detailed to express and requires extended time to execute in critical battle situations. Following the principles of menu design for the first three layers of tasks, we realized that menu layout could obscure map information that is constantly portrayed on the screen. To address this issue, we considered the use of function keys displayed on top of the screen. Also, icons at the top of the display screen would represent the functions in the menu.

Several design improvements are indicated below, mostly drawn from our analysis and those included in Hromadka (2001), Paap and Cooke (1997), and Darken and Sibert (1996). The most critical new feature is a multi-layered menu system, as shown in Figure 4. Other features such as status identifiers are located at the top of the screen above the map display. These status indicators are the battery status, satellite signal strength and GPS time are constantly displayed. Images on the screen will show friendly forces in element size, enemy forces in size if known, obstacles, waypoints and the current location of the PLGR itself. To prevent disorientation, navigation cues, waymarks and mini-maps are suggested (Sutcliffe, 2003). To this end, a map of the current location will be displayed as a background to the PLGR display. On the map several unique features will be displayed that are direct reflections of the information the soldiers need as determined by the task analysis. Among these features are unit representations, both friendly and enemy, using U.S. standard military unit designations. A friendly force will be shaded green and an enemy force will be red. Obstacles will be red triangles consistently and may be configured together to present a single point, a line, triangle or a square.

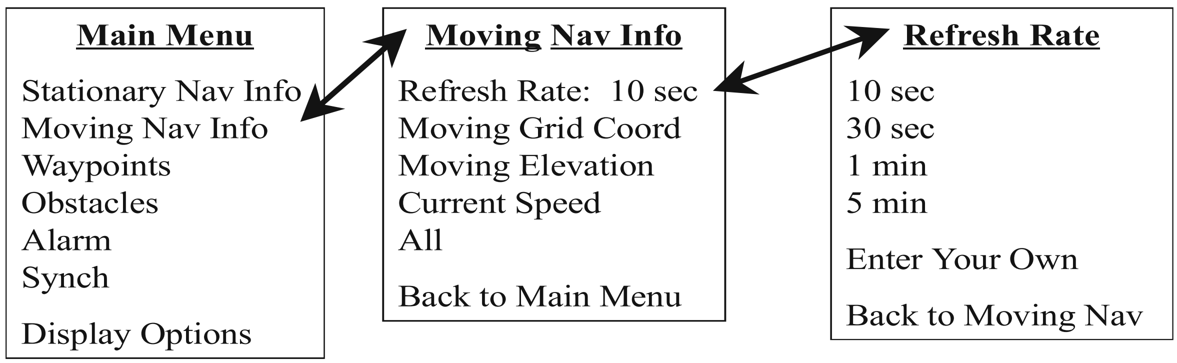

Figure 4. A cascading menu redesign for the PLGR.

The interaction provides for the user to input from one to four designating grid coordinates to mark the obstacle. A waypoint will be presented as a circle with the corresponding number of the waypoint inside the circle. This representation of a circle is consistent with the standard military symbols. The soldier / PLGR's current location will be centered on the display. This main piece of information will be boxed and set in white and yellow font with a transparent greenish background. The exact location will be a green square with an "x" denoting the center and actual grid location. Within that box the navigational information the soldier requested will be displayed.

After the solider requests specific navigational information, the PLGR will respond with: "Your Grid: 12ABC 12 34 56 78" or "Your Destination: 12 ABC 12 34 56 78". These are examples of text that the PLGR will provide the soldier in addition to the grid coordinate. We decided to include this idea of a reconfirming statement because Nielsen's Ten Usability Heuristics states "recognition is better than recall." By applying this heuristic, we realized that the soldier needed feedback to specify the meaning of the grid coordinate he or she is reading. In a situation where the soldier is multi-tasked and under pressure there is high potential for the soldier to forget what information he or she requested.

The display of the PLGR will have a map representation in a dark green color as the background. Major contour lines and terrain features will be illustrated on the map in brown in order to allow the soldier to quickly recognize the correctness of the information. The background map serves as a reference for the soldier to compare with the specific map he is using or to get a quick image of his location in relation to major terrain features or other elements on the map (such as obstacles, waypoints, or other friendly locations). Any bodies of water will be illustrated in blue on the map to distinguish them from the contour lines. It is also important to note that the map representation is irrespective of the type of land (i.e. desert, snow, and jungle) that the PLGR is presenting on the screen. All of this information is intended to be background support and this map is not intended for detailed terrain analysis or navigation with the background map alone. The dark green color of the map background also provides a dark background on which the critical navigational information can be displayed in sufficient contrast (e.g., white and yellow). And, an additional benefit to the dark background is that it will not emit a large light signature in a nighttime or blackout environment. Grid lines will be presented on the screen with the grid numbers associated with each line displayed on the extremes of the page for reference.

4. CONCLUSION

The techniques for designing interfaces on desktop systems do not apply well to handheld devices. In mobile devices, screen resources are limited, memory and processor powers are reduced, and two-hand and multiple input modes are in limited use. Therefore, if applied indiscriminately, the result is devices that are difficult to use, with small text and confusing graphics, and little contextual information for user interaction (Brewster and Murray, 2000). In this case, PLGR is a complex positional and navigational device used in critical and stressful battlefield situations. The user-centered methodology used in this paper has helped to highlight design inconsistencies and improvements, and illustrates that judicious use of existing principles can improve design efficiency. Task analysis and STN described were also useful tools to ensuring that a product redesign is purposeful and responsive to the needs of the user. We believe that with the new design, it is less likely for a soldier to cause friendly fire incidents, while using the device in combat situations. Further analysis of the PLGR could include a detailed analysis of the display color combinations, iconic shape/size configurations, and color contrast/saturation ranges.

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