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DESIGN AND CONTROL SESSION

User Centered Design Approach to an Integrated Dynamic Positioning System

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L-3 Dynamic Positioning and Control Systems

Abstract

Operating Dynamic Positioning (DP) Systems can be a challenge for operators especially when failures occur. Usability is a vital aspect of the system, especially in emergency situations. This paper presents a new development which emphasizes on the usability of a DP system. Advancements in modern User Interface design and technology have been incorporated in this effort to integrate full DP functionality into automation and navigation systems including radar, ECDIS, alarm, vessel and power management systems. With relatively few detailed requirements related to human factors from classification societies and owners, domain expertise and operator experiences have been heavily relied upon in the development.

This paper describes the development process from the conceptual stage to integration, through the design and development cycles, including several rounds of user feedback sessions. The concepts of usability and Situation Awareness (SA) are discussed and we illustrate with examples how human factors were translated into system requirements which ultimately affected the design. We will present results from the user feedback sessions, describe some of the challenges we met during the development and also describe the final software and hardware architectures. Design and implementation details related to touch screen interface will also be discussed.

Introduction

User Centered Design (UCD) is a design philosophy where the user's needs, wants, and limitations are made a focus during the lifecycle of design and development. The standard ISO 9241-210 also refers to this as human centered design and describes the requirements and recommendations for design principles and activities used during the process.

"Making interactive systems more human-centred has substantial economic and social benefits" (ISO 13407). A good usability translates to minimal number of errors using the system, increased user satisfaction which leads to effective and efficient job completion. With obvious benefits, UCD has been in practice in the aviation industry and plant management, but not in the marine industry. UCD requires a development process characterized by 1) active involvement of users and clear understanding of user and task requirement, 2) appropriate allocation of function between users and technology, 3) the identification of design solutions and 4) multidisciplinary design (ISO 13407, 1999).

An example of applying human factors into the Maritime industry is described by [Petersen, Et. Al.] for the development of the NACOS Platinum product line. The development of this product utilized a multi-disciplinary design team including external human factors representatives to implement a UCD process. The development described here is to some extent a continuation of the former and the key human factors experts joined the team for this effort.

The current L-3 DP Human Machine Interface (HMI) had evolved from a DOS based system with an external control panel for operator input to a Windows based system utilizing a Touchscreen interface. The HMI of the 6th generation system, and the versions prior to it, were designed by engineers (and some would argue for engineers) – little or no attempt was made to incorporate human factors into the design process. The development of the Platinum DP HMI presented a unique design opportunity to "start from scratch" and use input from a multi-disciplinary team to create a design incorporating human factors principles. Additionally it provided the opportunity to harmonize the look and feel of the DP software to fit in with integrated navigation and automation systems that are currently available in the NACOS Platinum product line. The development of the Platinum DP software implemented a similar UCD process as was done for NACOS Platinum.

Development Process

Incorporating usability goals into the development of a system requires that all relevant stakeholders are brought together to develop a common vision on how to incorporate usability. For the development of the Platinum DP software the relevant companies were identified so that overall goals for the system could be identified.

The context of use of the system consists of the factors of user group, tasks, technical environment, physical environment, and organizational environment [Maguire]. In order to better facilitate the HMI design a collection of use cases was developed to test the design against these factors. Identification of the user group was rather straightforward as the users were DP trained personnel who had at least a minimum of required training and knowledge of DP operations. Task identification was heavily used in the development of use cases by identifying what the common actions in DP operations are. Examples of some of these use cases that are performed at a high frequency are turning various sensors and position references on and off, entering or exiting DP, and performing set point maneuvers. These use cases would later be used in the evaluation of the design to ensure that they can be performed in an efficient manner. An example of a use case derived from the physical environment is changing the brightness and color levels of the HMI for changing between operations in different light conditions. Another example is silencing and acknowledging alarms present on the system.

The next stage of the development process was the identification of the requirements for the design. One requirement which carried over from the previous versions of the DP software was operation by using a touch screen interface. This imposed some obvious constraints upon the design because buttons, or any item that the user may interact with onscreen, should have a minimum size. The current trend in consumer electronics is strongly moving towards touch interaction in the form of tablets, phones, music players, etc. It was desired that the DP software should follow these current trends and use touch in a similar manner. A particular challenge here is the lack of right-click context menus which are commonly provided for mouse operated systems. In most cases this was addressed by simply selecting a design that does not need these types of context menus. In the case of alarm handling a context menu that opens upon touching the alarm lines allows for a single alarm do be acknowledged or disabled. Another requirement was integration of the DP software with the Platinum suite of applications. To ensure consistency among applications a style guide for the Platinum platform was consulted. This style guide provided consistent font types and sizes, general application layout, and sizes for buttons and other screen elements. The integration allows for an operator to switch among applications with a common look and feel. Additional requirements were developed to provide the operator with good situational awareness and overview of the status of the DP system, which is particularly important in failure scenarios. Finally, additional detailed requirements came from the mandatory display of overview data specified by regulatory bodies.

The initial stage of the design included a simple exercise formally known as card sorting. “Card sorting is a technique for uncovering the hierarchical structure in a set of concepts” [Maguire]. Screenshots of the current HMI were printed and cut up into their smallest elements. Engineers and users of varying experience were then instructed to organize the cut-outs into logical groups and sub groups. The team’s usability experts collected the groupings and analyzed the result to find the best grouping of the display elements. The results from this grouping exercise provided the initial requirements for the display layouts such as identifying the most important elements that should be always visible on the permanent display area. Examples of the results from the card sorting exercise and the resulting grouping of UI elements are shown in the images below.

Examples from Card Sorting – UI Elements broken down and arranged into groups.

Once the card sorting exercise was completed an initial design session was conducted in order to specify how the overall application layout would look like, how screen navigation would work, and the general layout of the DP screens. This was done in a way to remain consistent with the design of the other applications within the Platinum suite. The initial design session proceeded from specifying the top level layout of the UI, down through the top level grouping of DP screens and what is available on each screen (ex under Power and Propulsion, Alarms and Diagnostics, etc.), and finally into the detailed design of each screen.

UCD principles were applied to optimize the space. Pages and dialogs were designed to be simple, consistent, and oriented to the tasks at hand, reducing complicated interaction with the system. Navigation was designed in a tiered tab and sub-tab view that quickly lets the operator access important information while shortcut links are also provided to frequently used pages. On backup consoles a multi-panel view was provided to the operator to view multiple pages of data simultaneously. All operations were designed to provide feedback to the operator so that he knows that an operation has been successful. Once the first pass of the design process was completed, internal testing against use cases was performed to ensure that the most important frequently executed use cases could be performed efficiently. Initial thoughts were

generally captured with whiteboards or sketches while more detailed designs were done by static screen mockups made in flash. The static images produced provided the first detailed design.

To provide the operator with instant SA a basic overview of the vessel's position and heading deviations was developed. This requirement was created because the main overview display has additional functionality, such as being able to pan away and view charts, so it may not always be directly obvious what the deviations are. This requirement was translated into the design of the "mini-bullseye". This element, which is always visible on the permanent area, displays control deviations both graphically and numerically on a small fixed scale ship display. Heading errors, along with limits, are shown using a heading tape display. Rate arrows are used to provide the operator with a quick overview if the deviations in either axis are increasing or decreasing. Another requirement derived from quick SA was to have an easily accessible way to determine the readiness of the DP system. This requirement was translated into the design of a system ready dialog. At the top level, this simply provides a top level indication, ready or not ready for DP. Expanding the dialog breaks down the indication into various subsystems such as position references, sensors, thrusters, hardware, and others. An indication is given whether each individual subsystem is ready for DP operation. Next to each indication is a link to the detailed page which will show the exact status of the sub system. This design is especially conducive to quickly assessing failure scenarios, where the operator does not have time to browse through every page to find the source of a problem.

The evaluation of the design was aided by the creation of a series of software prototypes. The end result of the initial detail design phase was a collection of images detailing all of the screens and dialogs needed for the DP software. By this time the integrated software framework was sufficiently developed to support a mock-up application. This allowed for the creation of a "Clickable Demo" that utilized the software framework for application switching, screen navigation and popup dialogs but all of the detailed screens were static images of the detailed design. This initial prototype was intended to present the design and allow for navigation of all screens during the evaluation process. Later software prototypes evolved the "Clickable Demo" by replacing the static screens and dialogs with "Live" versions as the detailed software development proceeded.

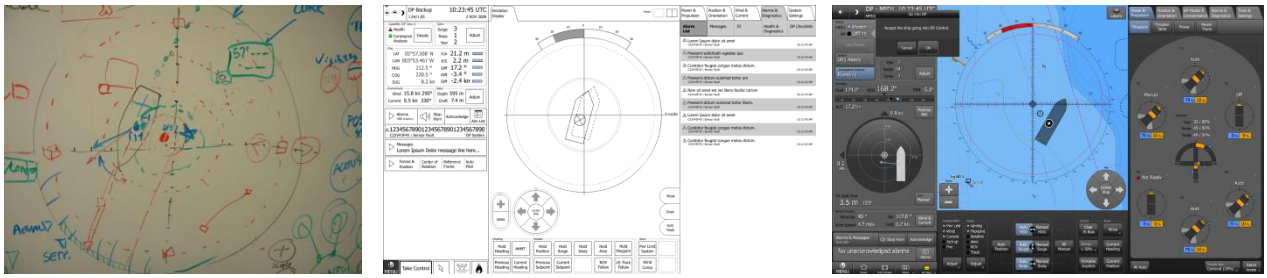
Further design sessions were conducted after the evaluation of end users. During this time feedback from the users was evaluated in detail by the design team. General comments were exchanged remotely at first, leading up to a design workshop where the team would meet and discuss certain aspects of the design and how to change them. These changes would be reflected in the next set of detailed design drawings and incorporated into the software prototypes used for additional evaluation.

Development Process - Evaluation

To evaluate the design, individuals with domain expertise and experience with DP operations were consulted. In order to get a good cross-section of the industry, individuals such as OSV operators, drilling operators and other industry professionals were consulted. This included individuals who were familiar with previous L-3 systems only, competitors systems only, as well as professionals with experience of both categories. Additional evaluations were performed with software engineers and service managers within the company, but who were not involved in the detailed design.

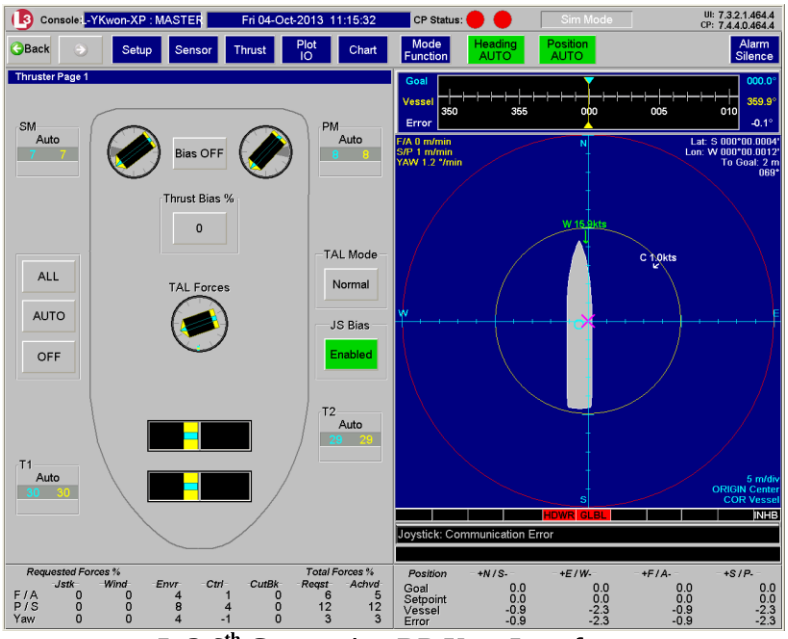
Evaluations were performed by setting up a computer to run the software prototype, which the individual would interact with. All audio during the evaluation session was recorded along with video of screen actions and of the individual. The recordings were taken for future analysis in case anything was missed during the evaluation session. One or more members of the design team were present to guide the evaluation. The evaluation was started by instructing the individual to navigate through the design, describing what they saw. Later, they were asked to walk through use cases for common DP operations using the prototype. Whenever the test subject had questions they were noted but not addressed until after the session. This was done so as to not affect the results by the answers given.

After a series of evaluations had been performed the comments from each evaluation session were consolidated and analyzed for commonality. If multiple similar comments indicated that some aspect of the design was unclear or confusing then this aspect was looked at in more detail. In total 419 issues were brought forward during the design evaluations, consisting of 14 evaluations across 7 represented companies. An example of a change commonly requested by the users was for easy access to the important pages such as position references and thrusters. To accommodate this request shortcut links were placed on a portion of the screen that is always visible allowing for these pages to always be a single click away. As another example the initial implementation of how to display bus loads and power cutbacks was unclear. This caused the displays used on the power pages to be reworked and the design updated.



Example of progression from whiteboard session to final design

Implementation of the software was done in a manner to stay as true to the developed conceptual design as possible.



L-3 6th Generation DP User Interface

L-3 Platinum DP User Interface

The benefits of UCD are noticeable when operating with the new HMI. Sensors and position references are grouped in a much more logical manner to provide an easier way for the operator to select what is used by the system. The interface for making position and heading maneuvers has been completely redesigned and provides a quick, intuitive way for the operator to enter a maneuver. Elements such as the mini-bullseye and the system ready dialog provide situation awareness and a quick way for the operator to view the current stationkeeping performance and a top level health indication of the system.

Conclusion

UCD principles have been applied during the development of the Platinum DP software which has been incorporated into the NACOS Platinum product line.

Integration was achieved through the use of common design as well as hardware and software platforms. Common design was achieved by applying the principles of UCD to all aspects of the integrated system, as well as having a common look and feel for all software applications. All the applications are developed in a common software framework and run on common Multi Function Displays which may be used for DP, Navigation, or Automation purposes.

During the development certain challenges were faced. Incorporating touch operation was challenging for both technical and design reasons. On the technical side, changes had to be made to the already developed integrated software framework in order to support touch interaction. For the HMI design, best practices had to be followed for sizing of screen elements requiring touch interacting as well as keeping the touch-friendly DP application faithful to the standard HMI design patterns implemented by non-touch applications in the integrated environment. It was sometimes challenging to be working in a multi-disciplinary team where opinions of how things should work, or why they are needed, sometimes vary greatly. Time zone differences among the involved companies made collaboration in real-time difficult. Utilizing existing software interfaces developed by other companies and fitting the DP application into existing workflow practices for developing integrated navigation and automation systems also required significant effort. In particular, integrating DP software alarms into an integrated system proved to be a particular challenge.

Despite the challenges mentioned above we strongly believe that the UCD process has benefited the development of the end product. Moving forward, plans are to continue to use UCD when any changes are made to the user interface or new features are added. In addition, the design effort is already underway for a portable operator workstation complimentary to the main DP stations that will incorporate the same process in the user interface design.

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