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A Human Factors Approach to Supervisory Control Interface Improvement

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1. Introduction

In recent years, control systems and the role of control room human operators have changed dramatically. Human operator activity has evolved from manually performing the process, to control system supervision. Today, the human operator requires an in-depth knowledge of the process that he/she is overseeing and the ability to make effective decisions within demanding constraints.

The increased complexity of industrial process control calls for a new methodological approach (for research and design purposes), which reproduces the essential components of current control systems: the environment, the task at hand and human operator activity (Samad & Weyrauch, 2000).

The complexity of industrial process supervision makes it necessary to supplement the Control Engineering approach with a cross-disciplinary cooperation in order to integrate knowledge and methods from other fields, especially Human Factors, Human-Computer Interaction and Artificial Intelligence (Granollers et. al., 2005), (Holstom, 2000), (Petersen, 2000). Our view is that complete control systems engineering must encompass all these approaches.

Human Factors is concerned with the adaptation of technology to suit human operator need and ability so as to achieve effectiveness, efficiency and user/worker satisfaction and comfort (Wickens et. al., 1997). In the domain of human factors in control room design the aim is to help engineers to design better systems and processes, increase operational safety and efficiency (Noyes & Bransby, 2001). One of the main references in telerobotics, automation and human supervisory control is Thomas B. Sheridan, who had an influence on professionals of the areas of engineering of systems and human factors along two decades (Sheridan, 1992). One of this author's main ideas is that the progresses in robotics do not only depend on the changes in the technology, but also on the advances in the understanding of the relationship between humans and machines. One example is the development of human interaction for multiple robotic systems that incorporate intelligent decision support capabilities via distributed artificial intelligence (Adams, 2006).
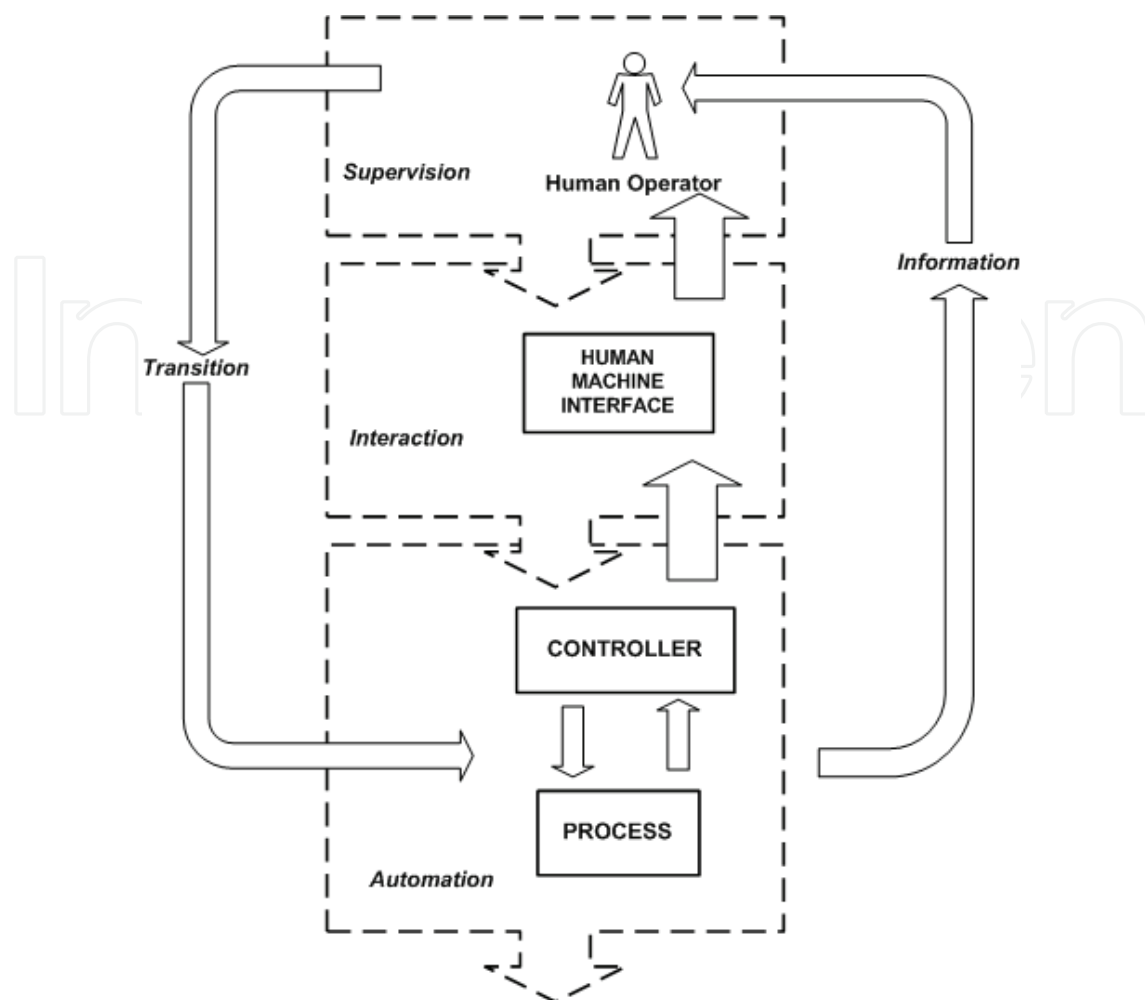
Fig. 1. A human supervisory control scheme in automation systems

Supervisory control is the set of activities and techniques developed over a set of controllers (programmable logic controllers and process controllers) which ensures the fulfilling of control goals. One of the main goals is to prevent possible plant malfunctions that can lead to economical lose and/or result in damage (Petersen & May, 2006). For this reason, other fields of knowledge concerned with manufacturing systems performance – such as maintenance and industrial security – are complementary in the study of supervision systems.

In Automation, Petri Nets (PN) have proved to be a successful approach on a broad range of applications (Kontogiannis, 2005). There is however one point that is not clears how to deal with within the PN formalism: the introduction of the operator (Lee & Hsu, 2006). Effectively, in every automation problem the fully automated part is just one part of the solution. It is customary that the operator can enter the loop in different ways, and such interaction needs to be considered as an integral part of the automation procedure as well as the communication of the automation device (usually a Programmable Logic Controller) with the operator. A human machine interface (computer display, industrial panel) is the connection between the human operator action and the input to algorithm control inside the controller (control based PC, control based PLC), (Ponsa et. al., 2007).

To these ideas it is necessary to add that the human and the interface cannot be considered in an isolated way, it is necessary to value that both, the human and the interface are in an

environment, for example the industrial environment of a petrochemical refinery. The human operator doesn't always understand or even feel the need to understand all the relationships behind the complex processes that they control via their interfaces. Furthermore, the human operators are not always aware of the constraints that affect the system that they work with, and discovering these constraints can take some extra effort (Burns & Hajdukiewicz, 2004). In this sense, the Ecological Interface Design EID incorporates this constraint based style in the design.

The cognitive ergonomics already includes this last idea inside the current conceptual framework named cognitive system engineering, in which it is described how the human centered design concept should be wrapped up from the perspective of the contextual design (Cañas, 2004), (Rasmussen et. al., 19994).

In this chapter a methodology for the creation of a human factor guideline for supervisory control interface design is proposed. In section 2 we present a checklist of indicators of the guideline called 'ergonomic guideline for supervisory control interface design' (GEDIS Guia ergonómica para el diseño de interfaz de supervision in Spanish version). The Sports Service Area project is described in section 3. The purpose is not to cover with detail the entire project but to give an idea of the different kind of topics that have been covered. In section 4, transition from the GEDIS model to Sports Service Area interface in control room is evaluated. In this section, a set of recommendations about graphical interface improvement are studied. Finally, conclusions and future research lines.

2. GEDIS guideline

Ergonomic criteria have been proved to increase the evaluation performance of experts (Reason, 1990). The previous research on human interface design guidelines includes for example the standard ISO 11064 that establishes ergonomic principles for the evaluation of control centers (ISO, 2004), the Human Factors Design Standards HFDS of the Federal Aviation Administration of the United States (Federal Aviation Administration, 1996), the Human Interface Design Review Guidelines NUREG 0700 in nuclear power plants (Nuclear Regulatory Commission, 2002), the I-002 Safety and Automation Systems NORSOK about Norwegian petroleum industry (Norsok, 2006) and the Man Systems Integration Standard NASA-STD-3000 about manned space programs (NASA, 1995).

An example of cognitive modelling in human computer interaction is the *Goals, Operators, Methods and Selection Rules* guideline, GOMS, in usability analysis (Card et. al., 1983). In combination with Keystroke-Level Model KLM an interface can be studied, also task execution time and human efficiency can be studied too.

In order to establish a relationship between ergonomics, usability and design process there is a variety of expert –review methods:
- Heuristic evaluation (the eight golden rules of interface design)
- Guidelines review (organising the display, getting the user's attention)
- Consistency inspection (the experts verify consistency of terminology, color, layout, etc.)
- Cognitive walkthrough (the experts simulate users walking through the interface to carry out typical tasks)
- Formal usability inspection (Palanque et. al., 2007)

A classical set of criteria for interface design to improve usability are the Ergonomic Criteria (Bastien & Scapin, 1995) and the Nielsen's Heuristic Guidelines (Nielsen, 1994).

The GEDIS guide is a method that seeks to cover all the aspects of the interface design (Ponsa & Díaz, 2007). From the initial point of view of strategies for effective human-computer interaction applied to supervision tasks in industrial control room (Nimmo, 2004), (Schneiderman, 1997).

The GEDIS guide offers design recommendations in the moment to create the interface. Also, already offers recommendations of improvement of interfaces created. The GEDIS guide is composed of two parts: description of ten indicators and measure of ten indicators. The indicators have been defined from extracted concepts of other generic human factors guidelines, and for aspects of human interface design in human computer interaction.

The method to continue for the use of the GEDIS guide is: analyze the indicator, measure the indicator, obtain the global evaluation index and finally offer recommendations of improvement.

For the correct use of the GEDIS guide it is necessary the collaboration between the control room technical team and the human factor technician, since in some cases to analyze the indicator is necessary the expert's opinion.

The subsection 2.1 shows a brief description of some relevant indicators, and the subsection 4.1 shows the measure of the ten indicators.

2.1 Indicators list

The GEDIS guide consists of ten indicators that seek to cover all the aspects of the interface design in the supervisory control domain. The indicators are: structure, distribution, navigation, color, text font, status of the devices, process values, graphs and tables, data-entry commands, and finally alarms. For example, the relationship between architecture and navigation indicators is illustrated in Fig. 1. The physical plant can separate in area, subarea, and local processes control[1]. In the same way, the interface presents four navigation levels. Fig. 2 shows a possible layout to locate all the connections between screens. The connection among screens is complex in a supervisory control interface. From the point of view of human computer interaction, is a typical example of cyclic network menu.

Distribution indicator of Fig. 3 shows a possible layout to locate all the objects inside the screen. The objects homogeneous distribution allows us to maintain the interface coherence when user changes the screen. The secondary objects are located in screen areas that don't require the user's attention (enterprise logo, and date/hour information). The user should recognize the screen title and the general navigation tool to move among screens. The main objects are located in visible screen areas (alarms, data-entry commands, subnavigation tool, and synoptic objects). The user can surveillance the process evolution without acting (human out of the loop), or he can decide to introduce changes in the set point or in the controller's parameters (human in the loop) inside a faceplate window in the data-entry command object. The user should have special attention to the alarm indicators, which should be located in a clear way in the screen so that the user can recognize the situation (situation awareness).

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[1] Each process control has is own structure. In example a sugar mill has the following parts: diffusion, evaporation, purification, sugar room, boilers, dryer, liquor storage, crystallisation
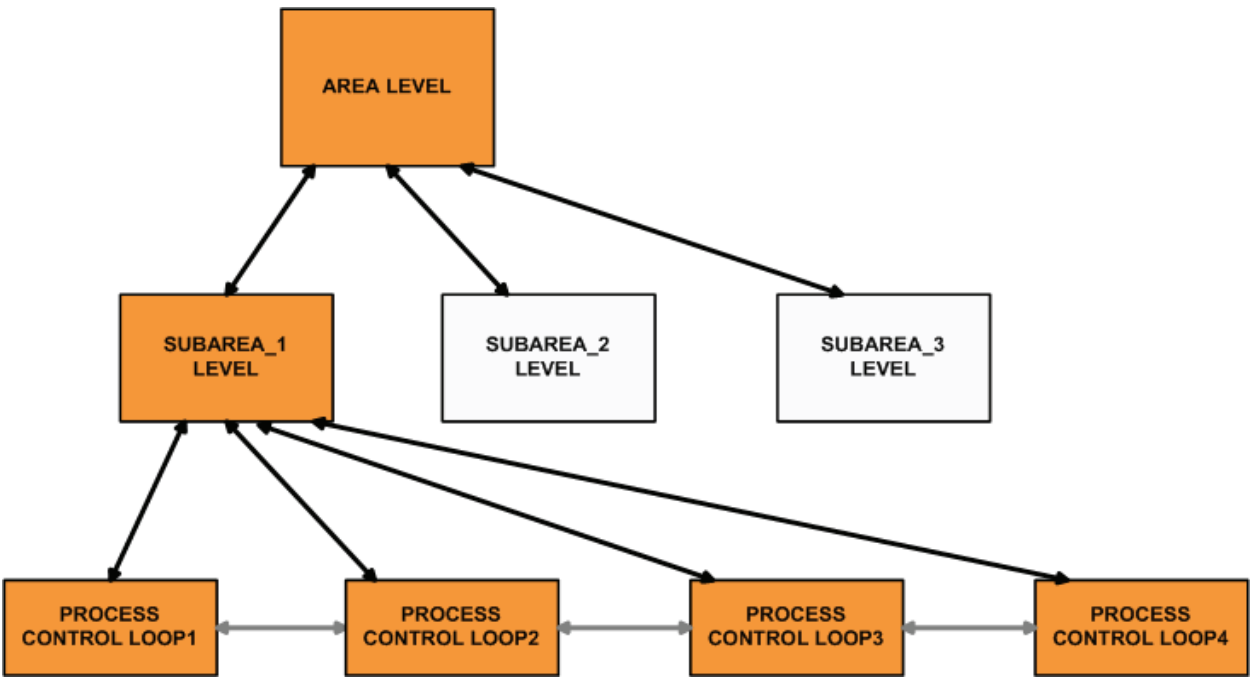
Fig. 2. A typical cyclic network menu in supervisory control interface associated to structure indicator. The arrow shows the navigation between screens.
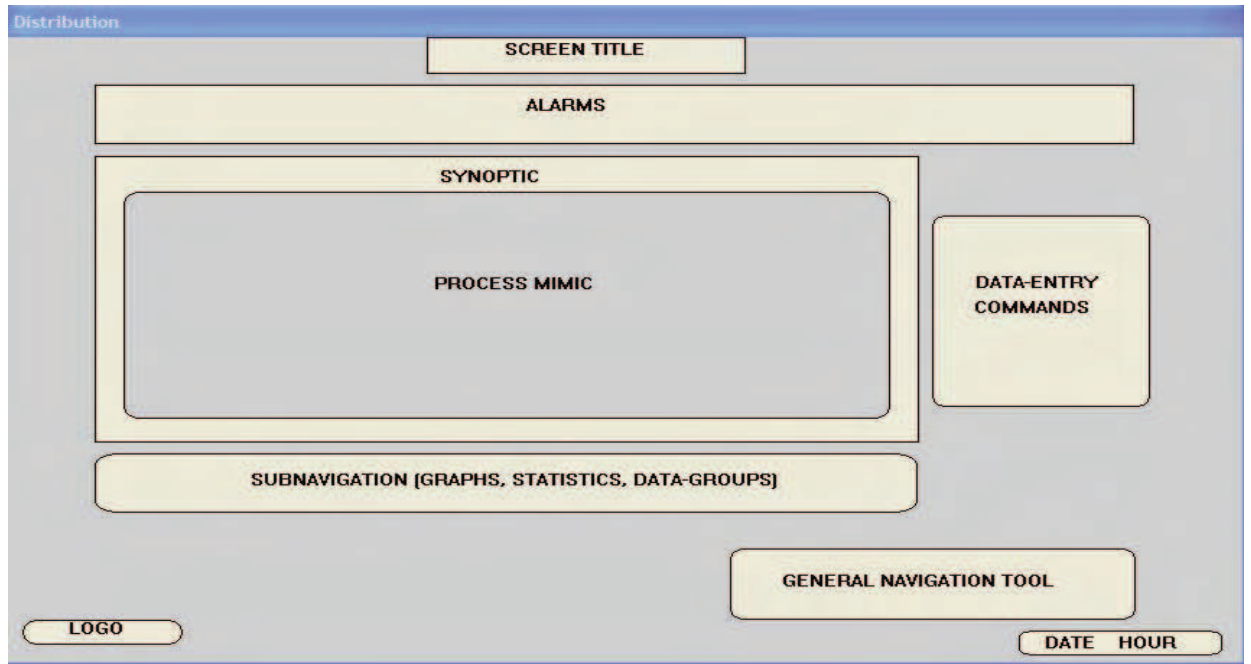

Fig. 3. An example of object's layout inside the screen for the distribution indicator

3. S.A.F. Project

This section presents the development of the supervisory control system, with special emphasis on the interface features, for the Sports Service Area (SAF in Catalan version) of the Universitat Autònoma of Barcelona (UAB). This supervisory control system has been developed by a team of Computer Science Engineers with common design guidelines. Even some basic principles on ergonomics and interface design were taken into account; the

GEDIS analysis will show existing weakness. An alternative presentation of the SAF project can be found in (Vilanova & Gomà, 2006).

First of all, it is worth to know that the UAB is a campus based university with more than 40.000 inhabitants (students, academics, staff, etc. In fact, this makes the University campus to behave like a city with some sort of facilities offered for their inhabitants (see Fig. 4).

Fig. 4. Main window of the developed monitoring system with a global view of the Sports Service Area

Among them, the Sports Service Area (SAF) is one of the largest and with more complex installations. It encompasses indoor as well as outdoor activities that run for more than 12h each day. Just to give an idea of the different installations that give support to the offered activities.

We can find there: covered swimming pool, boulders, outdoor facilities for tennis, football, athletics, etc., indoor installations for fitness, basketball, aerobic, gym, etc. (Antsaklis et. al., 1999), (Astrom, 1999), (Kheir et. al., 1996).

Therefore, large complexes build up from different subsystems. Each one of these subsystems has to assure a quality of service each day. This fact introduces the need for good monitoring tools to help on this task. In addition, there is a hug number of automation and control problems (automated watering, temperature controls for water and indoor areas, lightning systems, ozone controlled system for water cleaning in covered swimming pools, etc.).

The SAF project has different automation levels: from field instrumentation and data collection, PLC programming and feedback loop configuration, to information integration on a SCADA system. The SAF project use PLC from different manufacturers (SIEMENS, GE-FANUC, Landys, and Mitsubishi).

All the data has been integrated through implementing the corresponding supervisory control interface with Wonderware suite called InTouch. The basic communications use specific drivers to connect PLC with PC based control; the advanced communications use the standard OPC protocol.

Fig. 5. An example of a Temperature feedback loop inside a SAF installation, and the ISA-PID control law used to close/open the regulation valve

An example: for indoor activities temperature control of both the SAF building and the water for the gym showers has been implemented. This means the students, in control room operator role, had to close some temperature feedback loops by using the ISA-PID control law present either in the PLC or in the software (see Fig. 5).

One important aspect of a monitoring system is how it deals with alarms. As this feature is a common feature, it should be incorporated in every part of the system according to the same rules. This way, in every SCADA window and alarm indicator has to be included that shows the human operator if an alarm is currently fired and can let you go directly to the main alarm window to process it.

Finally, design implementation and configuration of the InTouch based SCADA system has been done starting from zero. This allowed to think of a distributed application where from the different computers located either at the main SAF office or at the technical staff room the overall system can be accessed. In addition a special access, using terminal services, for the technical staff has been enabled so remote operation can also be done from outside the SAF installations.

4. S.A.F. evaluation

The connection between SAF designer and GEDIS guideline designer is necessary to define a global evaluation of the SAF interface and can give a set of recommendations about graphical screen improvement (see Fig. 6).

In general, heuristic evaluation is difficult for a single individual to do because one person will never be able to find all the usability problems in an interface (Nielsen, 1994). In this evaluation, the number of evaluators is seven groups of control engineering students. The heuristic evaluation session have been 6 hours. Some groups have been concentrating in a specific part of the SAF interface and a specific indicator (see Table 1). The advanced groups have been evaluating the SAF interface with the entire GEDIS guide.
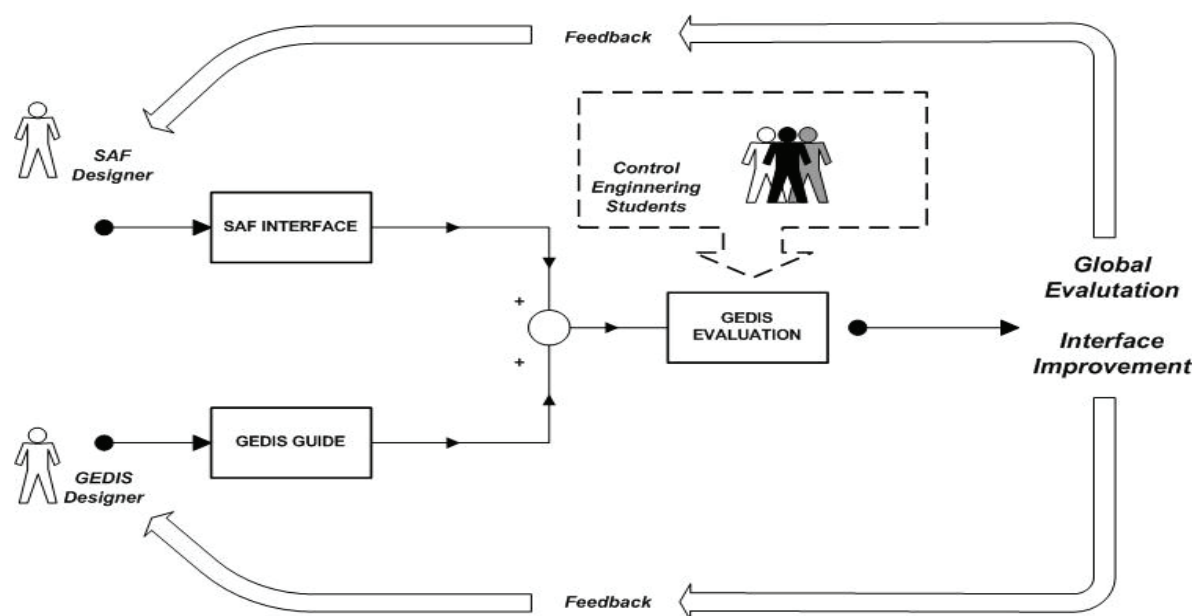
Fig. 6. The GEDIS method includes: the SAF interface evaluation, the control engineering students in the role of usability evaluators, the SAF technical staff and the GEDIS designers.

Usability Evaluators (Control engineering students)	Evaluation of SAF Interface with the GEDIS guide
Group (two students)	
1	Alarms indicator 2,9
2	GEDIS guide global evaluation 3,1
3	Status of the devices indicator 3
4	Structure indicator 3
5	Navigation indicator 3
6	GEDIS guide global evaluation 3,5
7	Distribution indicator 3

Table 1. The number of usability evaluators is seven groups of control engineering students at the Technical University of Catalonia (EPSEVG school)

4.1 Evaluation

The evaluation expressed in quantitative numeric form or in qualitative format it seeks to promote the user's reflection that stuffs the GEDIS guide by way of questionnaire, so that it picks up the use experience that doesn't end up being verbalized in many occasions. Each one of the indicators of the Table 2 and Table 3 can substructure in diverse subindicators. For example, the indicator Color can be detailed in: absence of non appropriate combinations (5), number of colors (5), blink absence (no alarm situation) (5), contrast screen versus graphical objects (3), relationship with text (3).

Indicator name and Subindicator name	Numeric/qualitative range and SAF numeric value
Architecture	**1,7**
Map existence	[YES, NO] [5,0] 0
Number of levels le	[le<4, le>4] [5,0] 0
Division: plant, area, subarea, team	[a, m. na] [5,3,0] 5
Distribution	**3**
Model comparison	[a, m. na] [5,3,0] 3
Flow process	[clear, medium, no clear] [5.3,0] 3
Density	[a, m. na] [5,3,0] 3
Navigation	**3**
Relationship with architecture	[a, m. na] [5,3,0] 3
Navig. between screens	[a, m. na] [5,3,0] 3
Color	**5**
Absence of non appropriate combinations	[YES, NO] [5,0] 5
Color number c	[4<c<7, c>7] [5,0] 5
Blink absence (no alarm situation)	[YES, NO] [5,0] 5
Contrast screen versus graphical objects	[a, m. na] [5,3,0] 5
Relationship with text	[a, m. na] [5,3,0] 5
Text font	**3,2**
Font number f	[f<4, f>4] 5
Absence of small font (smaller 8)	[YES, NO] [5,0] 0
Absence of non appropriate combinations	[YES, NO] [5,0] 5
Abbreviation use	[a, m. na] [5,3,0] 3

Table 2. GEDIS guide indicators (part one), where a = appropriate , m = medium and na = no appropriate

For each subindicator it is recommended it is punctuated numerically in a scale from 1 to 5. In this example the number of of subindicators of the indicator Color is J = 5 (see formula 1). The formula necessary to calculate the numeric value of each indicator is the formula 1.

$$Indicator = \frac{\sum_{j=1}^{J} w_j Subind_j}{\sum_{j=1}^{J} w_j} \tag{1}$$

where, *Subind*= subindicator and w = weight.

The mean value that one obtains by the formula 1 with these numeric values is 4,2 . If it is rounded, the value is 4, so that to the indicator Color it is assigned the value 4 in this example, considering that each one of the subindicators has the same weight (w1 = w2… =wj = 1).

Each one of the indicators of the Table 2 and Table 3 are measured in a scale from 1 to 5. The human expert operator prepares in this point of concrete information on the indicator, so that it can already value the necessities of improvement.

The values of the indicators can group so that the GEDIS guide offers the global evaluation of the interface and it can be compared with others interfaces.

Indicator name and Subindicator name	Numeric/qualitative range and SAF numeric value
Status of the devices	**4**
Uniform icons and symbols	[a, m. na] [5,3,0] 3
Status team representativeness	[YES, NO] [5,0] 5
Process values	**3**
Visibility	[a, m. na] [5,3,0] 3
Location	[a, m. na] [5,3,0] 3
Graphs and tables	**4**
Format	[a, m. na] [5,3,0] 3
Visibility	[a, m. na] [5,3,0] 3
Location	[a, m. na] [5,3,0] 5
Grouping	[a, m. na] [5,3,0] 5
Data-entry commands	**3**
Visibility	[a, m. na] [5,3,0] 3
Usability	[a, m. na] [5,3,0] 3
Feedback	[a, m. na] [5,3,0] 3
Alarms	**3,8**
Visibility of alarm window	[a, m. na] [5,3,0] 3
Location	[a, m. na] [5,3,0] 3
Situation awareness	[YES, NO] [5,0] 5
Alarms grouping	[a, m. na] [5,3,0] 5
Information to the operator	[a, m. na] [5,3,0] 3

Table 3. GEDIS guide indicators (part two), where a = appropriate , m = medium and na = no appropriate

The formula necessary to calculate the GEDIS guide global evaluation index is the formula 2.

$$Global\_evaluation = \frac{\sum_{i=1}^{10} p_i ind_i}{\sum_{i=1}^{10} p_i} \qquad (2)$$

where, *ind* = indicator and *p* = weight.

In a first approach it has been considered the mean value among indicators expressed in the formula 2. That is to say, to each indicator it is assigned an identical weight (p1 = p2… =p10 = 1) although it will allow it in future studies to value the importance of some indicators above others. The global evaluation is expressed in a scale from 1 to 5. Assisting to the complexity of the systems of industrial supervision and the fact that an ineffective interface design can cause human error, the global evaluation of a supervision interface it should be located in an initial value of 3-4 and with the aid of GEDIS guide it is possible to propose measures of improvement to come closer at the 5.

4.2 Experimental study

The experimental study is the evaluation of SAF interface with the collaboration of control engineering students from Technical University of Catalonia. From Vilanova i la Geltrú city,

twenty four students monitoring SAF interface around three weeks. The students define a numeric value for each indicator and propose interface improvement (see Tables 2 and 3).

The SAF interface global evaluation is 3,4. The global evaluation is expressed in a scale from 1 to 5, so it is necessary to indicate SAF designer a set of important recommendations:

- Revise the relationship between structure, distribution and navigation indicators. There is a lack of coherence in some subareas
- Create a global map screen to support aid to human operator
- Improve the feedback between interface and human operator in data-entry commands indicator
- Improve the easy location of alarm indicator in each screen
- Improve the alarms classification in each subarea
- Build an alarm log with the abnormal situations and create variables as: the average alarm rate, the most frequent alarm, the longest-standing alarm and any regulary repeating alarms (Andow, 1998), (Bransby, 1998), (Bransby & Jenkinson, 1998)
- It is necessary to create a survey and evaluate the human operator performance and satisfaction with the use of the SAF interface
- It is necessary to create a training program to support the transition from novice to expert operator

With GEDIS guide is possible too to indicate SAF designer a set of important recommendations about graphical screen improvement. For example, the Piscina ACS screen can improve with a set of changes in color and text font indicators (see Fig. 7).

A second example, the Fronton and Rocodrom screen can improve with a set of changes in distribution indicator (see Fig 8).

5. Conclusions

In tasks of human supervision in industrial control room is habitual that an external engineer, - by means of the commercial programs Supervisory Control and Data Acquisition SCADA -, take charge of designing the supervision interfaces in function to the knowledge on the physical plant and the group of physical-chemical processes contributed by the process engineers.

Although standards exist about security in the human machine systems that impact in aspects of physical ergonomics, interface design by means of rules of style, it is remarkable the absence of the design of interactive systems centered in the user where the engineering usability and the cognitive ergonomics can contribute significant improvements (Nielsen, 1993).

The GEDIS guide is an approach that tries to fill a methodological hole that joins the efforts of the systems engineering and the human factors for the improvement of the effectiveness of the human-machine system in industrial control room.

The application of the GEDIS guide to the study of cases contributes among other details the measure in form of indicators of aspects of interface design, the recommendation of changes for the improvement of the interface, and a global evaluation index that allows to quantify the current state of the interface regarding the future state after applying the correct measures.

The studied case presented shows a Spanish academic application, Sports Service Area S.A.F., but with the same characteristics of an industrial project. With the GEDIS guide approach it's possible to perceive diverse anomalies and to propose improvements in the interface design. The technical staff of the S.A.F. project are working in introduce the important recommendations in order to improve the interface design and the usability.
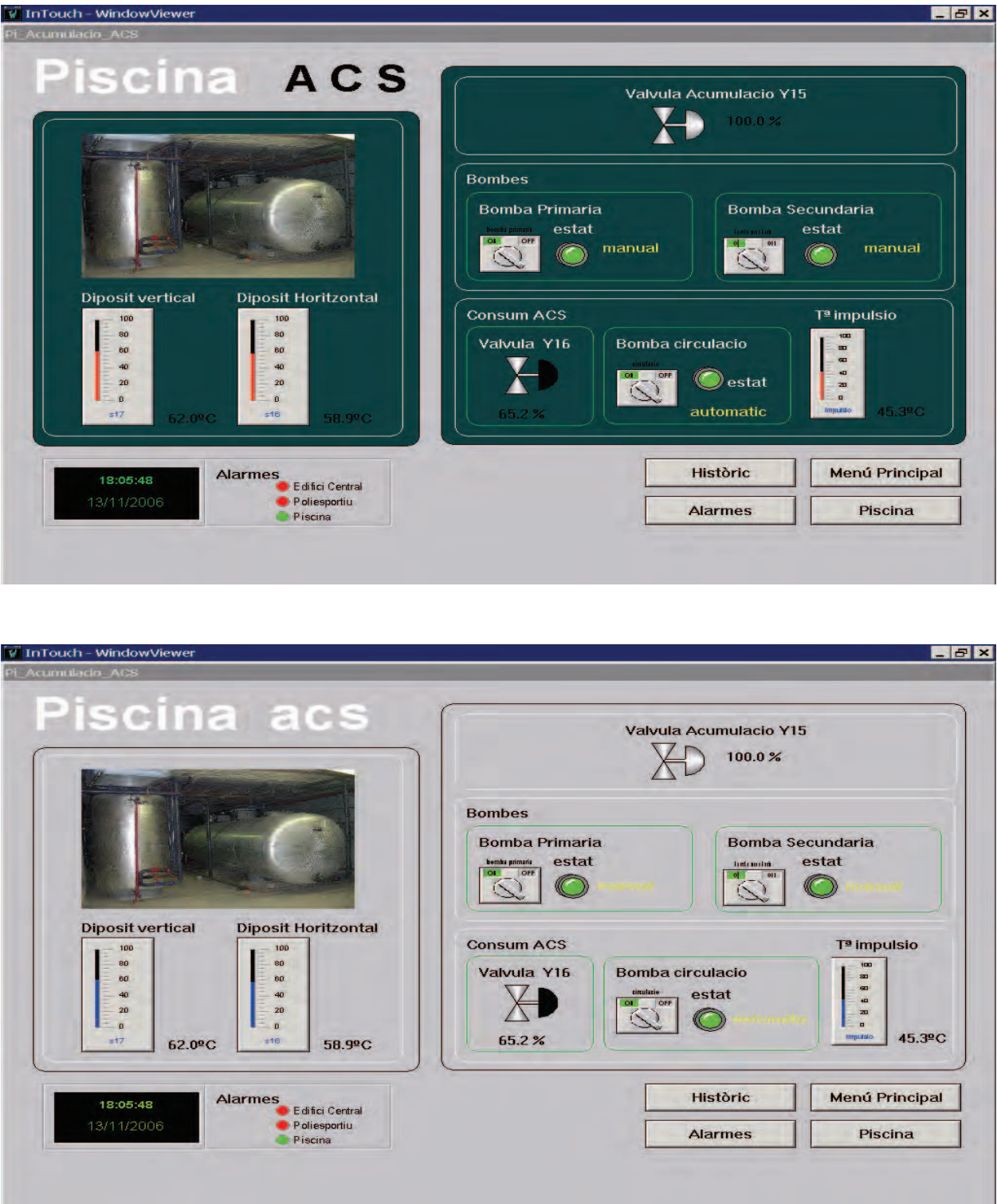
Fig. 7. Original Piscina ACS screen (top): There is confusion between the green screen color and the green color of the pumps display. The tank level display (left) shows a red bar in a situation without alarm. Piscina ACS revisited (bottom) with changes in color indicator. The screen color is now grey and the user can visualize better the states of the pumps display. The tank level display (left) is now a blue bar (the red color is only for alarm displays).
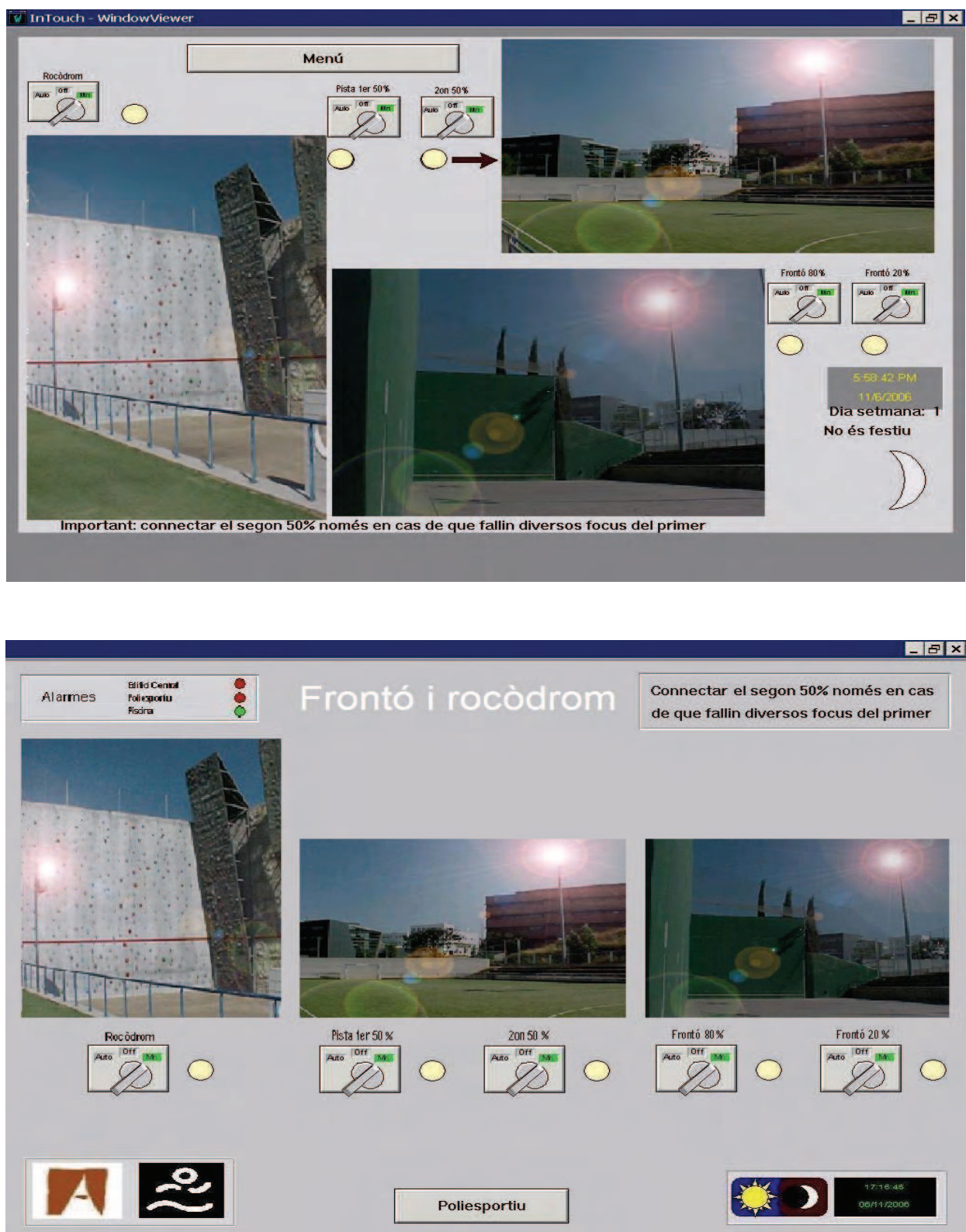
Fig. 8. Original Fronto and Rocodrom screen (top). There is a disorder between switches and photos in this screen. Fronto and Rocodrom revisited (bottom) with changes in distribution indicator. In this screen the user doesn't need to remember where each switch is; the distribution reduces the workload.

Another current study with the GEDIS guide is the analysis of a sugar mill interface. The Sugar Technology Center (CTA) in Spain has been developed a training simulator to modeling and simulating the production process and the human operators' supervisory tasks. The simulator developed in this center is an example of full scale simulator, a type of simulator that reproduces the whole operating environment (Merino et. al., 2005). This simulator emulates the control room of a sugar mill. A series of object oriented modelling library tools are used to create each part of the sugar mill: diffusion, evaporation, purification, sugar room, boilers, dryer, and liquor storage.

In these moments the 4all-L@b Usability Laboratory of the Technical University of Catalonia is analyzing the GEDIS guide to simplify the number of indicators of the guide, to improve the evaluation method, create new usability metrics, and to promote the use of the guide inside the cycle of life of the software engineering, in this case in the early phases of the supervisory control interface design.

8. References

Adams, J.A. (2006). Supporting human supervision of multiple robots. *The Journal of the Robotics Society of Japan,* Vol 24(5), pp. 17-19, ISSN: 0169-1864

Andow, P. (1998). Abnormal situation management: a major US programme to improve management of abnormal situations. Paper presented at IEE Colloquium on *Bet Practices in Alarm Management*, London. March.

Antsaklis, P.; Basar, T.; DeCarlo, R.; McClamroch,N.H.; Spong, M. & Yurkovich, S. (1999). Report on the nsf/css workshop on new directions in control engineering education. *IEEE Control Systems Magazine*, (10), pp 53-58, ISSN: 0272-1708

Astrom, K.J. (1999). Automatic control: the hidden technology. P.M. Frank ed. *Advances in Control: Highlights of ECC-99*, pp. 1-28, ISBN: 1852331224

Bastien, C. & Scapin, D. (1995). Evaluating a user interface with ergonomic criteria. *International Journal of Human-Computer Interaction,* Vol 7(2), pp-105-121, ISSN: 1044-7318

Bransby, M.L. (1998). Explosive lessons. *Computing and Control Engineering Journal,* 9, pp. 57-60.

Bransby, M.L. & Jenkinson, J. The management of alarm systems. HSE Research Report no CRR 166/1998.

Burns, C.M. & Hajdukiewicz, J.R. (2004). *Ecological Interface Design.* CRC Press, ISBN: 0-415-28374-4

Cañas, J.J. (2004). *Personas y máquinas*. Editorial Pirámide, Colección Psicología, ISBN: 84-368-1893-8

Card, S.; Moran, T.P. & Newell, A. (1983). *The psychology of human computer interaction.* Lawrence Erlbaum Associates, Inc., ISBN: 0898598591

Federal Aviation Administration (1996). *Human factors design guide for acquisition of commercial-off-the-shelf subsystems, non-developmental items, and developmental systems (DOT/FAA/CT-96/01).* Atlantic City International Airport, DOT/FAA Technical Center

Granollers, T.; Lorés, J. & Cañas, J.J. (2005). *Diseño de sistemas interactivos centrados en el usuario*. Editorial UOC, Colección Informática, No 43, ISBN: 84-9788-320-9

Holstom, C. (2000). *Human factors and control centre issues. What lessons we have learned.* Institute for Energy Tecnology, OECD Halden Reactor Project

ISO International Organization for Standarization (2004). *Ergonomic design of control centres, parts I, II, III, IV*. In URL: http://www.iso.org

Kheir, N.A.; Astrom, K.J.; Auslander, D.; Cheok, K.C.; Franklin. G.F.; Masten, M. & Rabins, M., (1996). Control systems engineering education. *Automatica* 32 (2), pp. 147-166, ISSN: 0005-1098

Kontogiannis, T. (2005). Adaptable task modelling and its application to job design for safety and productivity in process control. In *ACM International Conference Proceedings*, Vol 132, pp. 27-34, ISBN: 9-60254-656-5

Lee, J.S. & Hsu, P.L. (2006). Applications of Petri Nets to human-in-the-loop control for discrete automation systems. In *Manufacturing the future: concepts, technologies, visions.* Edited by Kordic, V.; Lazinica, A & Merdan, M., Pro Literatur Verlag, pp. 167-194, ISBN: 3-86611-198-3

Merino, A.; Alves, R. & Acebes. L.F. (2005). A training Simulator fot the evaporation section of a beet sugar production. *European Simulation Multiconference, ESM-05*, Oporto, Portugal.

NASA (1995). *Man system integration standards*. NASA-STD-3000, In URL: http://msis.jsc.nasa.gov/

Nielsen, J. (1993). *Usability engineering.* Academic Press, Boston, ISBN: 0-12-518406-9

Nielsen, J. (1994). Heuristic Evaluation. In Nielsen, J. & Mack, R.L. (Eds), *Usability Inspection Methods.* John Wiley and Sons, New York, ISBN: 0-471-01877-5

Nimmo, I. (2004). Designing control rooms for humans. *Control Magazine*, pp. 47-53, ISSN: 1049-5541

Norsok Standard (2006). *I-002 Safety automation system.* Norwegian Technology Centre Oscarsgt. 20, Postbox 7072 Majorstua N-0306 Oslo. In URL: http://www.olf.no y http://trends.risoe.dk/detail-organisation.php?id=52#corpus

Noyes, J. & Bransby, M. (2001). *People in control: human factors in control room design.* IEE Control Engineeering Series 60, London-

Palanque, P.; Basnyat, S. & Navarre, D. (2007). Improving interactive systems usability using formal description techniques: application to HealthCare. *HCI and Usability for Medicine and Health Care, LNCS, November, pp. 21-40, ISSN:0302-9743*

Petersern, J. (2000). *Knowledge based support for situation assessment in human supervisory control.* Ph.D. Thesis. Department of Automation. Technical University of Denmark.

Petersen, J. & May, M. (2006). Scale transformations and information presentation in supervisory control. *International Journal of Human-Computer Studies*, Vol 64, 5, May, pp. 405-419, ISSN: 1071-5819

Ponsa, P., Vilanova, R. & Díaz, M. (2007). GEMMA Guide Approach for the Introduction of the Human Operator into the Automation Cycle. *Inf. tecnol.*, 2007, vol.18, no.5, p.21-30. ISSN 0718-0764.

Ponsa,P. & Díaz, M. (2007). Creation of an ergonomic guideline for supervisory control interface design. *12 th International Conference on Human-Computer Interaction.* July, Beijing, P.R. China. In URL: http://www.hcii2007.org , LNCS 4562, pp. 137-146, ISSN: 0302-9743

Rasmussen, J.; Pejtersen, A.M. & Goodstein, L.P. (1994). *Cognitive Systems Engineering.* New York, Wiley, ISBN: 0-471-01198-3

Reason, J.T. (1990). Human error. Cambridge University Press, Cambridge.

Samad, T. & Weyrauch, W. (2000). *Automation, control and complexity.* John Wiley and Sons, ISBN: 978-0-471-81654-6

Schneiderman, B. (1997). *Designing the user interface. Strategies for effective human-computer interaction.* Addison-Wesley, third edition, ISBN: 0-201-69497-2

Sheridan, T.B. (1992). *Telerobotics, automation and human supervisory control.* MIT Press, ISBN: 0-26219-316-0

U.S. Nuclear Regulatory Commission (2002). *NUREG-0700, Human-system interface design review guidelines.* Office of Nuclear Regulatory Research, Washington DC 20555-0001. In URL: http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0700/nureg700.pdf

Vilanova, R.; Gomà, A. (2006). A collaborative experience to show how the University can play the industrial role. *7th IFAC Symposium on Advances in Control Education*, June, Madrid, Spain. URL: http:www.dia.uned/ace2006

Wickens, C.D.; Gordon, S.E. & Liu, Y. (1997). *An introduction to human factors engineering.* Longman, ISBN: 0-321-01229-1

Robotics Automation and Control

Edited by Pavla Pecherkova, Miroslav Flidr and Jindrich Dunik

ISBN 978-953-7619-18-3

Hard cover, 494 pages

Publisher InTech

Published online 01, October, 2008

Published in print edition October, 2008

This book was conceived as a gathering place of new ideas from academia, industry, research and practice in the fields of robotics, automation and control. The aim of the book was to point out interactions among various fields of interests in spite of diversity and narrow specializations which prevail in the current research. The common denominator of all included chapters appears to be a synergy of various specializations. This synergy yields deeper understanding of the treated problems. Each new approach applied to a particular problem can enrich and inspire improvements of already established approaches to the problem.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Pere Ponsa, Ramon Vilanova, Marta Díaz and Anton Gomà (2008). A Human Factors Approach to Supervisory Control Interface Improvement, Robotics Automation and Control, Pavla Pecherkova, Miroslav Flidr and Jindrich Dunik (Ed.), ISBN: 978-953-7619-18-3, InTech, Available from: http://www.intechopen.com/books/robotics_automation_and_control/a_human_factors_approach_to_supervisory_control_interface_improvement

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