A Co-operative Simulation Approach to the Design and Evaluation of Visual Interfaces in a Train Driving Cab.

Peggy ZWOLINSKI
UTBM Sévenans - L'ERCO
90010 Belfort Cedex, France
peggy.zwolinski@utbm.fr

Valérie GOUIN
UTBM Sévenans - L'ERCO
90010 Belfort Cedex, France
valerie.gouin@utbm.fr

Jean-Claude SAGOT
UTBM Sévenans - L'ERCO
90010 Belfort Cedex, France
jean-claude.sagot@utbm.fr

Abstract

This paper presents a co-operative approach used to design visual interfaces in a train driving cab. This method was elaborated with the help of engineers, ergonomists, and volunteer train drivers. During this design project, ergonomists studied the usefulness and the usability of visual information, in relation to future driving cab control devices. The use of virtual rapid prototyping, necessary for the user interface evaluation, was a real support to increase co-operation between engineers and ergonomists for the design of the future driving cab. It appeared that the virtual display designed with rapid prototyping was a real support for the Collaborative Design and Concurrent Engineering.

1. INTRODUCTION

The extension of the European train network and the evolution of technologies have led ALSTOM Transport to think about the introduction of displays on train board. Indeed, the differences between the technical requirements of the different networks and the differences between railway cultures require more adaptable driving desks. So, ALSTOM Transport decided to realise a project based on a Concurrent Engineering process, to standardise their locomotive driving desks by using adaptable visual interfaces on displays.

To realise this project, the customer ALSTOM TRANSPORT (engineer, computer engineer,...) met train drivers, responsible from the French national railway and members of the ERCO (ergonomists, psychologist, ...).

The aim of this paper is to illustrate the pragmatic methodology used to create a more efficient visual system for train driving cab which lead the project group to a real co-operative work concerning the design of the future driving cabs. It presents a user-centred approach using simulation with rapid prototyping, to create visual interfaces.

? The first section of this paper concentrates on data concerning existing visual interfaces in driving cabs. This first stage of the simulation approach enables us to build an accurate model of the present situation.

? In the second section we will show how to design the future activity in a co-operative approach using scenarios and by analysing the functions of the interface. We will explain why the use of rapid prototyping was necessary to evaluate the interface with eight train drivers and was also very useful for designers in the Preliminary Study of this concurrent engineering project.

2. ANALYSIS OF EXISTING VISUAL INFORMATION

The first step in this study was to collect data concerning visual information and to its use influence during the driving activity. Indeed, this analysis of the driving activity is very important to point out factors which would help us to improve or transform existing working conditions and thus design a man-machine interface. So, the project group :

? listed the existing solutions concerning trains, metros,...in European countries. We examined the different components in the driving cabs, their physical characteristics, the reason of their existence and ergonomic aspects of each component,

? examined the driving task (driving rules, driving devices, technical evolution of control devices,...) to realise analysis concerning visual interfaces,

? interviewed and observed drivers at work during trips with French train drivers. We have observed the driving activity with a diesel and with an electric locomotive, in passengers and freight service, by day or by night (Fig 1, Fig 2). According to Zwolinski and Sagot (1998), we have taken into account objective measures (eye directions, blinking frequency, ...). So we have consulted existing results concerning high speed trains studies used on classical railways.

Fig 1. Electric locomotive driving desk (22200)

Fig 2. Electric locomotive driving desk (26000)

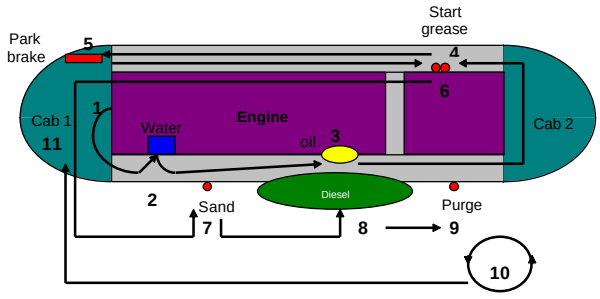
Then we worked with ergonomists, cognitive ergonomists and six train drivers in order to determine what happens concerning visual information in classical situations. We defined scenarios about what can happen before, after and during a trip and identified with train drivers this classification concerning visual information :

? Visual information to check the train and start it (levels, malfunctions,...).

? Visual permanent information during the driving activity (speed, traction,...).

? Visual information events during the driving activity (alert, dysfunction,...).

For example, on the basis of the scenario Fig 3, we have identified all the information required to check and start an old designed diesel locomotive.



1. switch on and check battery
2. check water level
3. check oil level
4. greasy
5. put off park brake
6. Start the engine and go out
7. start and check for sand
8. diesel level
9. purge
10. check mechanical parts
11. go inside and read board default notice

Time to proceed about 15 min

Fig 3. Actual general scenario :
check and start a diesel engine.

Most of problems in existing systems come from the lack of a global ergonomic view of the whole system. It appears that the main problems of current visual interfaces are :

? too many visual information,

? they are not adaptable,

? the ergonomics of existing visual systems are not very good.

For example, we were confronted with a wide variety of solutions, to display the available level of traction depending on the locomotive's type.

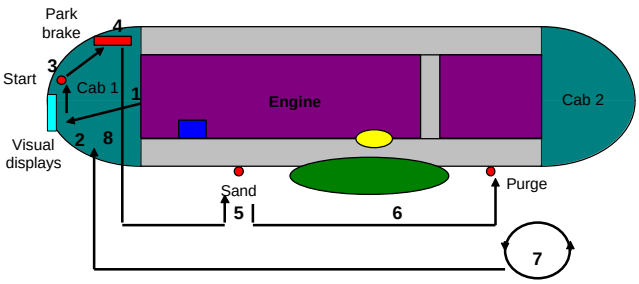
All these considerations have led the project group to determine, what we called, according to Sagot et al. (1997), "the field of desirable future activities " concerning visual interfaces, desirable in terms of safety, comfort and efficiency. Then, members of the project group wrote the functional specifications, the ergonomics specifications, and defined a large number of technical principles.

3. PRELIMINARY STUDY FOR THE DESIGN OF VISUAL INTERFACES

3.1. Definition of the Future Scenarios

To detail the field of future activities we generated new scenarios (Fig 4) concerning the activity of the train drivers. For each action defined in a scenario, we can detail the visual information required by the drivers.

With this analysis, we validated the usefulness of the actual visual information and identified new information to be presented to the driver.



1. switch on battery
2. watch visual display : board default (if present) and check water - oil - diesel levels
3. start (greasy) of the engine
4. put off park brake and go out
5. start and check for sand
6. purge
7. check mechanical parts
8. go inside

Time to proceed about 10min

Fig 4. Example of a future general scenario : check and start a diesel engine.

The notion of field of desirable activities, and scenarios came from a mean to keep a common language between all the actors of the project group taking into account all the aspects of the project (functionality, available data, technical aspects,...).

3.2. Design of Visual Interfaces Concepts

As mentioned by Beevis and Denis (1992), when designing large systems, mock-ups are generally scheduled late in the preliminary phase because the required detailed tasks analysis to specify the human machine interface is not available earlier. So, according to Keyson and Parsons (1990), we consider that rapid prototyping must be used in an iterative approach to design development and we decided to use it earlier in the design process. Indeed, the notion of field of desirable activities and scenarios permit to construct mock-ups with rapid prototyping to experiment principles earlier in the project.

All mock-ups proposed meet the criteria defined during the functional analysis, according to Sanders and Mc Cormick (1992), and three classical aspects were examined on visual displays :

? the structure of the interface

? the structure of the information

? the presentation of the information

At this step of the study, rapid prototyping enabled us to completely integrate ergonomic aspects of the product. It was necessary to obtain an acceptable solution including all the aspects of train drivers activity.

Indeed, during the advanced design stage of this project, all information concerning future cabs were not completely defined. So, Mock-ups of the visual interfaces were a real support to detail the general activity of train drivers.

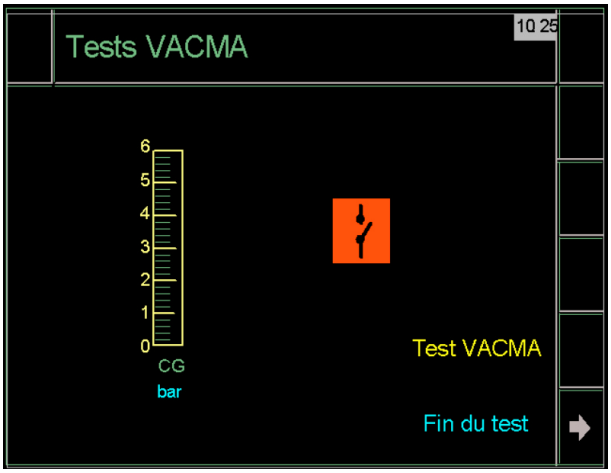


Fig 5. A page constructed with rapid prototyping

Then we have verified, according to Vinck and Jeantet (1995) that the mock-ups (Fig 5), also called « intermediate objects », play a threefold role as : a translation of organisational objectives, an intermediary among designers and an image of the project being pursued.

3.3. First Evaluation of Visual Concepts

As mentioned by Beevis and Denis (1992), rapid prototyping or « Virtual prototyping » of human-machine interfaces, offer the possibility to put the human operator « in the loop ». So we realised, according to Sweeney and al. (1993), a first classical evaluation of accepted concepts with eight train drivers (Fig 6) by examining usability indicators like user performance, behaviour, knowledge,...

Fig 6. A train driver during the first evaluation of displays

3.4. Discussion Concerning the Preliminary Study for the Design of Visual Interfaces

The results concerning the first evaluation enable us to verify :

? the validity of the functional principle of the visual system,

? the appropriateness between adopted design logic and the driver stereotypes,

? comprehension simplification as a result of the grouping and organisation of visual information.

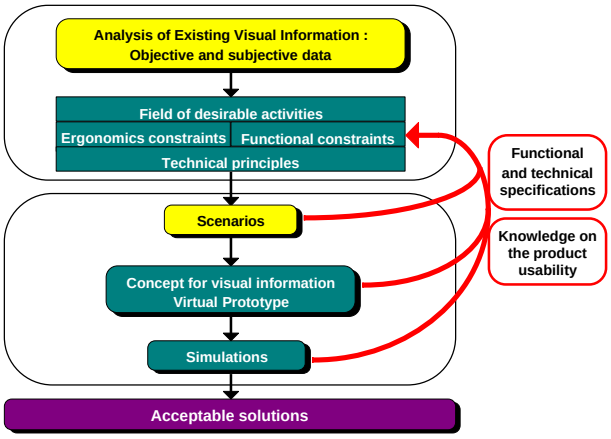


Fig 7. General approach during the preliminary study for the design of visual interfaces.

Thus, the simulation approach during the preliminary study (Fig 7) has allowed us to make an initial validation of visual information.

As pointed out by Tessier and al. (1999), we were able, on the basis of our results, to verify design criteria concerning some aspects of the usability concerning the concept. We have shown that mock-ups realised with rapid prototyping are really « new mediating objects », in these kind of projects, to translate ideas, for mediation and to give a representation of the future project for all members of the project group.

4. CONCLUSION

The design methodology, described in this paper, presents our experience with a simulation approach to develop visual interfaces. This method had the merit of associating several partners : manufacturers, ergonomists and operators taking into account different opinions to define the final concept.

In fact, the organisation of the work of design in firms is closely linked to the type of « intermediate objects » used (texts, graphs, models, mock-ups, etc.), as mentioned by Vinck and Jeantet (1995). In this project, we used rapid prototyping to design simultaneously intermediate objects about the product and its usability (Fig 8). The notion of "field of desirable future activities", developed by Sagot and al. (1998) was central to our work and rapid prototyping was a mean to consider it.

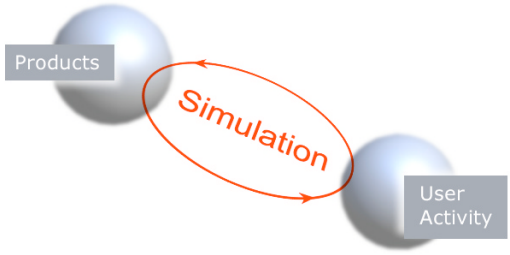


Fig 8. Simulation to design simultaneously products and user activity

Moreover, we demonstrated that the simulation approach allows representative end-users to provide inputs into the design, testing and modification sessions which are necessary to determine an acceptable solution. It constitutes a useful solution to have a user centred approach and a co-operative design. Rapid prototyping, essential during the preliminary study, can also be used in every steps of the study. Indeed, during detailed study, mock-up realised with rapid prototyping will be evaluated on a train simulator in order to evaluate the whole future system.

5. ACKNOWLEDGEMENTS

The authors extend their thanks for providing support for this study to ALSTOM Transport in particular to JM. TESSIER and T. GUINARD and to the SNCF, in particular to S. LE DOARE and JP. BERNARD. Thanks to all the French drivers for their participation and to all the members of the ERCO team who have actively participated in the realisation of the experiment.

6. REFERENCES

Beevis D., St Denis G,1992. Rapid prototyping and the human factors engineering process. Applied ergonomics, Vol. 23, Number 3, pp207-213.

Keyson D.K., Parsons K.C., 1990. Designing the user interface using rapid prototyping Applied ergonomics, 21.3, pp207-211.

Sagot JC., Gouin V., Lorinquer JP., Chappet P., 1997. The high speed train : an ergonomic approach for the driving cab design. In :World Congress on Railway Research. 16-19 November, Florence (Italy), vol. A, pp843-851.

Sagot JC., Gomes S., Zwolinski P, 1998. Vers une ergonomie de conception : gage de sécurité et d'innovation. International Journal of Design and Innovation research, Vol. 1, n°2, Novembre, pp22-35.

Sanders M., MC Cormick, 1993. Human factors in engineering and design. McGRAW-HILL international editions, seventh edition, 789p.

Sweeney M., Maguire M., Shackel B., 1993. Evaluating user-computer interaction : a framework. Man-Machine studies, n° 35, pp689-711.

Tessier J.M., Guinard T., Le Doare S., Bernard JP., Zwolinski P., 1999. Presentation of a range of driving desks for locomotives. In :World Congress on Railway Research. November 99,Tokyo, 9p.

Vinck D., Jeantet A., 1995. Mediating and Commissioning objects in the Sociotechnical Process of Product Design : a conceptual approach. COST Social Sciences serie, CCE, pp111-129.

Zwolinski P., Sagot JC., 1998. A simulation approach to the design and evaluation of auditory interfaces in a high speed train driving cab. The fifth International Conference on Auditory Display (ICAD 98), University of Glasgow, November 1-4, 10p.