Automation for improve of mental workload of the systems engineer.

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Abstract: This paper is a feedback of an original approach to standardize the work of electric traction of railway transportation. This work was developed within an industrial thesis, financed by the SNCF (French acronym for National Society of French Railways) in association with the CReSTIC (Research Centre in Information and Communication Science and Technologies). Thanks to Systems Engineering approach around standardization and safety programs, the systems engineers' concentration on cognitive task has been improved. After 2 years of implementation, some results are analysed.

Keywords: control, task-based design, mental workload, standardization process, safety-critical systems, railway transport.

1. INTRODUCTION

The competition of the European rail transportation due to the opening of the market imposes to the National Society of French Railways (SNCF) to set up innovative solutions improving the productivity. These solutions must not be to the detriment of the safety of installations and persons from which the engineering of the SNCF infrastructure is a guarantor. Moreover, the work of systems engineers evolve and their workload around automation tools too (Young and Stanton, 2008).

In SNCF, the electric traction engineering department (called IGTE) is in charge of the specification of the equipment of telecontrol, automation and Low Voltage (LV) protections of the Power Supply Equipment of the Electric Lines (PSEEL) market. The PSEEL are the electrical supply points of the electrified lines, called catenary. The role of the PSEEL is to transform, to supply, even to rectifier in the case of DC supply, the tension of the High-Voltage (HV) network into compatible tension with traction units (1500 V DC, 25 kV AC or 2x25kV AC). A traction substation is an electrical substation that converts electric power from the form provided by the electrical power industry to an appropriate voltage, current type and frequency to supply railways with traction current (Fig. 1). A traction substation has (very) High-Voltage devices as switches, circuit breakers, protection and control equipment, to ensure safety (EN 50126) in case of electrical danger to persons and properties (Fig. 2).
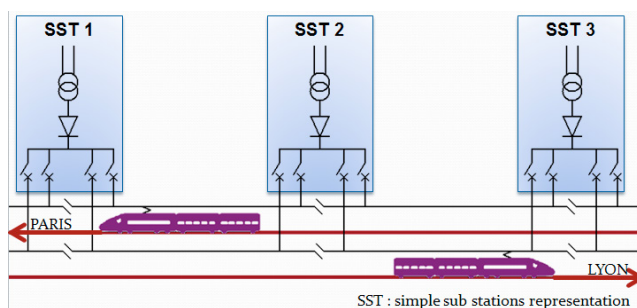

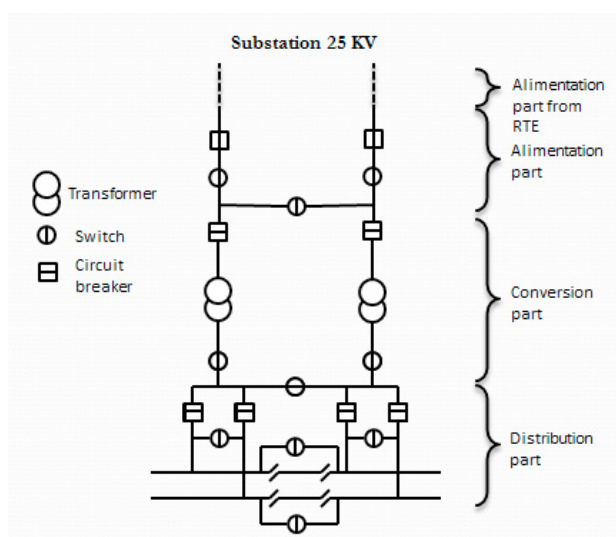Fig. 1. Traction Substation System.

Fig. 2. Traction Substation Devices.

The PSEEL are distributed automated systems among which control-command can be done locally but also remotely, in a centralized control station (Gilmore et al., 1989) called Central Sub-Stations (CSS). The human supervisors can activate HV devices (switches, circuit-breakers…) since this control room. They are responsible for ensuring the supply of

PSEEL under nominal and degraded modes (maintenance of catenary voltage) to ensure safety when working on PSEEL or catenary under national regulations (UTE C 18510) or specific and emergency shutdown in case of electrical danger to persons and properties (Fig. 3).
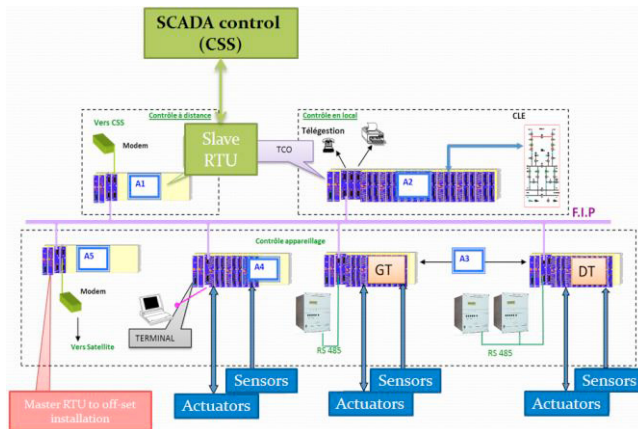

Fig. 3. Distributed Control.

To increase competition, the electric traction engineering department of the SNCF has prospected around two axes of improvement. The first one is the standardization, in order to improve the homogeneity of deliverables made by the technical studies. Standardization can also integrate the generation of deliverables (documents, schema...). The deliverables generation allows optimizing the working time of the systems engineers by avoiding them to enter redundant data. The improvement of the working conditions involves a regulation of their mental workload by avoiding the errors consecutive to the mental underload and to the peaks of overload. The second one is the implementation of a robust filter based on safety constraints (Riera et al., 2012) to ensure the safety of persons and PSEEL whatever is the functional control implemented in Programmable Logic Controller (PLC). The program must respect standard language (IEC 61131-3). This control safety filtering should be used to prevent control errors that may be sent from CSS.

In a previous work (Coupat et al., 2013), we have presented the theoretical influence of these two axes on performance and mental workload of the systems engineer (Fig. 4). In 2013, it was not possible to measure the effect of the proposed approach on the life cycle of the PSEEL. To bring these results, it was necessary to wait to have an experience feedback over a significant duration to be able to compare with existing systems.

This paper is a feedback of 2 years of results and exploitation. Section 2 reminds the methodology to improve engineer work. Firstly by the use of a software tool for standardization, and secondly by the application of a robust filter. Section 3 talks about the mental workload results in project workflow of a systems engineer. It is described each phase of a project and the impact of standardization and use of robust filter. Conclusion and future works are in section 4.
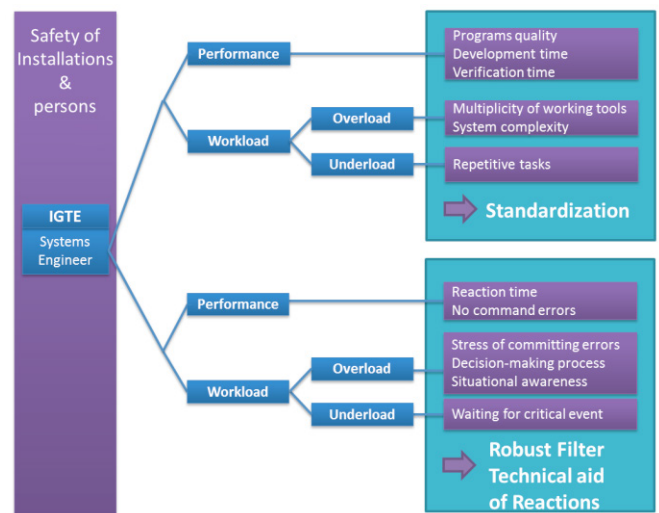

Fig. 4. Representation of the solutions proposed to increase performance and mental workload.

2. METHODOLOGY TO IMPROVE ELECTRIFICATION PROJECT OF PSEEL

Firstly, the solution is based on the principle of unique data entering, this allows optimizing the workload. The description of the PSEEL in this unique software environment should allow generating all deliverables (documents, programs, wiring diagrams ...). This software solution is a part of a process of work standardization. Secondly, the implementation of a robust filter based on safety constraints (Riera et al., 2012) to ensure the safety of persons and PSEEL whatever is the functional control implemented in Programmable Logic Controller (PLC). This control safety filtering should be used to prevent control errors that may be sent from CSS (Fig. 5).
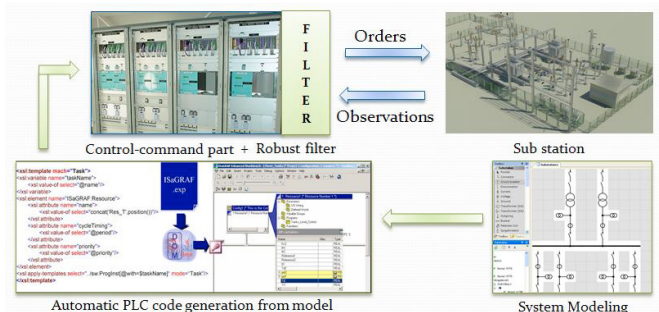

Fig. 5. Application of standardization and robust filter.

2.1 Software for standardization

Standardization of a job is a process requiring the domain know-how and having a global vision (job expert). It is therefore natural that the first phase of this approach is a study of all the principles used by the job to understand the know-how. Indeed, the workflow methodology followed by the systems engineers is composed of steps shown in Figure 6.