Organisational simulation: anticipating the ability of an organisation to cope with daily operations and incidents

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Abstract. Ergonomic simulations are common in architectural, technical or computer design processes. The same conditions can be used to carry out an organisational simulation, in order to test the ability of an organisational structure to cope with different situations, including normal planned operations and incidents. A case study in a high risk industry is presented.

Keywords. Organisational simulation, ergonomics, constructive ergonomics

1. Introduction

Simulations are a well known method to test the usability of a new product or device. They are extensively used in ergonomic interventions in industrial or architectural projects, to test the compatibility of the work means with human characteristics, anticipate future work activity, detect possible malfunctions or hazards, and suggest modifications right from the design stage. They can also be used to test the ability of an organisational structure to cope with different situations, including normal planned operations and incidents.

Organisational simulations are commonplace in logistics, where mathematical models and software are used to check the fluidity of a process and detect possible bottlenecks. The type of organisational simulations that is proposed here is rooted in the practice of ergonomic simulations of future activity in new systems. The aim is to assess the degree of leeway that is left by the organisational structure to the human activity, the critical contradictions that can appear between the objectives that are set and the resources that are allotted, and the possible consequences in terms of human cost, safety, or effectiveness.

The conditions for this type of organisational simulation are the same as described by Daniellou (2007) for any ergonomic simulations: the required elements are the social construction of the overall participatory process, the choice of the participants, the choice of the simulation media and the type of simulation, the choice of simulation scenarios.

This paper describes these elements in the case of an organisational simulation carried out in a high risk industry.

2. A case study: general frame

2.1 The industrial request

A petrochemical company decides to make a major investment in one of its Seveso plants, aiming to increase the production while the numbers of workers remains stable. The

planned changes in "S" unit include new process equipment, and a new work organisation including regrouping of "S" with a distant unit "L".

The technical project team was in the same site but at a distance from the production units. It included former production managers, but had few contacts with present production leaders.

The plant manager, who has been made sensitive to Human Factors, asks the ergonomists: "Will our future organisation be safe?" The ergonomic team is made up of an academic, a consultant, and a senior adviser of the Institute for an Industrial Safety Culture. The intervention started three years before start-up of the new unit, and required 60 person-days over 7 months.

2.2 The intervention steps

The intervention was initiated by presentations to a steering group and to personnel representatives.

The first step was the analysis of existing activities in "S" and "L" units. After obtaining the required habilitations, the three ergonomists observed all posts (control room and external operators, supervisors, maintenance coordinators), each during at least one shift. Detailed accounts were redacted. These observations, among other results, showed the importance of what were considered as "coffee breaks" but were in fact synchronization periods of the representations of the state of the process and of the ongoing field operations for the whole team. It was also demonstrated that many operations required the simultaneous presence of at least two operators (operations with respiration isolating device, heavy valve handling, etc.). Physical workload was described. Daily workload peaks (signature of work permits and fire permits, lock and tag operations, sample analysis) were also identified during this in-depth study.

At the same time, the ergonomists got acquainted with the planned changes in the process and in the organisation, by means of documents and interviews of the design team. Drawings and 3D representations of the future process were gathered.

The second step was the construction by the ergonomists of scenarios likely to challenge the planned organisation. Some of these were daily operations (including routine inspections tours). Some scenarios were based on more or less serious process incidents in both units "S" and "L" (steam fall, power cut, etc.). Incidental scenarios were validated by the process engineer, some of them based on detailed reports of past real incidents, some others including specific features of the new equipment.

The third step was the organisational simulation. Since the ergonomists "felt" that there might be problems with the organisational structure planned by the company, they proposed to have a first simulation round only with the project leaders and unit managers (without shop floor operators). The detailed progress of the simulation is presented below. This first simulation round stopped after a few hours, since it revealed that the planned organisation did not even permit the smooth realization of normal inspections in a quiet work day. Particularly, it was impossible for the team members to gather at the same time in the control room for a common "break" or better said "synchronization". This was a critical issue for operators' situational awareness of the process. Ambiguities in the roles of the supervisors were also spotted. Team reactivity to cope with unexpected events was also affected and "weak" periods regarding safety were identified with the planned task division (specific skills missing on "S" unit while performing routine tour on "L" unit) .

The unit managers then worked out a second organisational proposal, which entailed a more extended domain of responsibility and habilitation for each operator, and required revising the training and habilitation program to increase polyvalence. The supervisors' roles were clarified. A second simulation round was launched, this time with the presence

not only of project leaders and unit managers but also of representatives of the shift operators and supervisors. During three days, all "daily" scenarios and four incident scenarios were tested as described below.

3. Organisational simulations in detail

3.1 Management of simulations

For each scenario, its content is first presented, and validated and/or completed by the participants. For instance, a proposed scenario was "It is 06:20 in the morning. An alarm on the control screen indicates a leak of (product X) in (place Y)" and participants suggested to add "wind is from south-east" (increasing the risks for the neighboring town).

Then a list is set of all operations that should be made by each member of the team to cope with the situation described. On a large whiteboard, operators are represented by lines and time periods by columns. The time for the realization of each operation is estimated from the operators' knowledge of distances and from the ergonomists' observations in the existing plant. Each operation is represented by a "post-it" label of appropriate length (time simulation, fig. 1)). This lay-out enables control of possible simultaneity of the presence of two or more operators to carry out one operation.

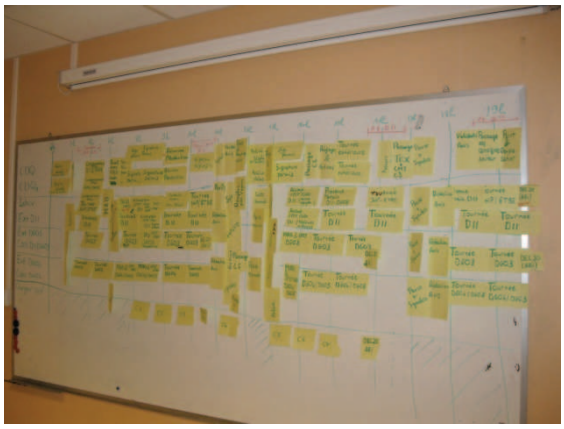

Figure 11: Example of a temporal simulation of an operation

Figure 2 : Spatial simulation

Simultaneously, each operation is dotted on the drawings of the planned process installations (spatial simulation or "Tom Thumb" simulation, fig. 2). When the use of ladders or stairs appears to be needed, the corresponding time is estimated and added to the time taken in account for the "post-it" simulation, as is walking time between different places.

At the end of the simulation, photos are made of the whiteboard and drawings, and an account is redacted using Excel forms.

3.2 Main results on the organisation

As indicated above, the first round of simulations showed that the initial organisational hypothesis was not viable. An extreme specialization of the workers' missions and habilitations made the system rigid, and did not even permit a proper synchronization between all inspection tours.

The second hypothesis, including more polyvalence, passed the tests of all prepared scenarios, including serious incidents, under some technical conditions indicated below. After presentation of these results to the steering committee, this led the plant management

to start negotiations with the personnel representatives, about a training and habilitation plan that included increased salaries in exchange of more polyvalence for the operators. Since simulations had been carried out more than two years before start-up, it was still possible to set an extensive training program.

The simulations revealed that some technical conditions should also be modified: a vehicle was needed for some distant operations; gangways were added between the top levels of several devices, to prevent climbing down and up ladders in the course of an operation; several manual valves were motorized to reduce the cases where several operators where needed to carry out one operations; sensors were added.

3.3 Side effects

Beyond the reframing of the organisation and the development of the training and habilitation program, several side effects were noted and expressed by the plant actors.

The presence of the ergonomists, their questions and the meetings they provoked reinforced the relations between the production leaders and the design team. Organisation, which was initially considered a subproduct of technical choices, became a key issue for the viability of the project. A number of technical details were changed due to the questions raised by the production engineer and/or the operators.

For the operators who participated in the simulations, these made possible an early and detailed understanding of the future plant lay-out, which they shared with their teams using the process documents, especially 3D representations.

Some of the production managers were surprised by the quality and importance of the operators' contribution to the simulations: many possible difficulties were detected through their questions, and many technical changes were made possible thanks to their suggestions.

Personnel representatives, that were used to imposed organisational changes, were surprised by the simulation outputs and the negotiation about upgrading of qualifications and salaries.

The production engineer in charge of the unit decided to use the "post-it" simulations as a general tool for the writing of operation procedures.

The plant manager asked the ergonomists to present their methods to all plant managers of the same branch.

On the other hand, the proposal made by the ergonomists to go on accompanying the last phases of start-up preparation was not accepted, the management considering that "they had learnt enough to go on by themselves".

A post start-up assessment was planned but has not been realized yet.

4. Conclusions

Organisational ergonomic simulations, like simulations regarding technical devices, are not only a method of assessment of possible consequences of a change in work means.

They are an opportunity to develop the activity of several actors (Barcellini et al., to be published). They contribute to the early discovery of the future system by the operators, and to their mastery over it. They modify the designers' decision processes, through an early confrontation between their proposals and the on-going work in the real world. They also change the position of the plant management, who is both the contracting authority with respect to the designers (with whom the discussions are mainly technical), and in a hierarchical position as regards the operators (which requires anticipation of future organisation, qualifications and training programs).

The question put in the center of the decision making processes is no longer "How will

the system operate?" but rather "How will we operate the system?". As mentioned by Béguin (Béguin and Pastré, 2002, Béguin, 2003), the simulations allow for a confrontation between different "worlds", each of which has a partial and oriented view of the system operation. The debates that take place during the simulations contribute to the construction of a "common world", each group getting acquainted with information and constraints that are usually the possession of other groups. The scope of variability of operating conditions to be considered is widened.

Obviously, it is not possible to anticipate through a limited number of scenarios all situations likely to happen in the future, and real variability will turn out to be even more important than already included in the scenarios. But all actors noted the difference of resilience between the first organisational hypothesis and the second one, after the first failed to pass easy tests, while the second passed the test of four critical and very different scenarios. More scenarios were tested under supervision of process engineer, with the same method, in the absence of the ergonomists.

In the case presented, the technical means required to carry out the organisational simulation are extremely limited. The conditions for a positive outcome are mainly an in-depth knowledge of the tasks to be performed in the unit, which cannot be derived only from written prescriptions but require prolonged observations, in order to build simulation scenarios likely to challenge the planned organisation.

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