# Integrated Human and Organizational Factors–oriented Design and Development Method

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**Abstract:** Safety-related industries have been interested in Human and Organizational Factors (HOF) for a long time. HOF integration in design and development projects is now widely recognized as a key factor in the success of such projects in delivering plants or systems that can be operated safely and efficiently. However, even the most comprehensive of HOF design approaches are based on the hypothesis that the design, development and evaluation phases of a project are sequential and focus their efforts on the design and evaluation phases.

Within the same period, the software development industry has seen the emergence of agile software development methods. Their goal is to produce software that meets the users' requirements without a very precise or comprehensive knowledge of these requirements at the beginning of the project. They promote an iterative, incremental and evolutionary approach and make operational proposals about project management and development team organization and practices so as to be able to integrate new or modified users' requirements during the project lifecycle.

The study presented in this paper is based on the hypothesis that these two approaches are complementary and can be combined to propose an integrated HOF–oriented design and development method. It includes a theoretical analysis of both approaches and feedback from several development projects led by EDF Research & Development using this innovative approach.

**Keyword:** ISOFIC, I&C, HMI, Design, Development, Human & Organizational Factors

## 1 From user-centered design to integrated HOF-oriented design and development

Agile methods and Human Organizational Factors (HOF) approaches in design are two different user centered design approaches. Although they come from different disciplines and apply *a priori* to distinct phases of the classical developmental cycle, they aim to solve the same problem, namely how to develop a system that responds to needs when they are poorly known, and are based on common principles: the process is centered on the end user and the satisfaction of his needs; the approach is iterative, the evaluation of intermediate solutions by the users allowing to specify, refine and update the needs; the design is collective, it involves users (in the case of agile processes, it is even fully participative because users take part in the design process and have decision-making power).

The HOF design approach is not limited to the design of the technical system only but considers the design of the socio-technical system, and can be defined as follows: "The aim is to make design decisions more reliable by anticipating the consequences of technical and organizational choices on human work that will take place under future operating conditions. To promote effective and safe human interventions, the HOF approach is based on a thorough analysis of human activity in existing situations and on a simulation of the probable activity in future operations, depending on the technical and organizational options that appear." [1]

However, even the most advanced of these HOF approaches in design assume that the design, development and evaluation phases are sequential and focus their efforts on the design and evaluation phases. The design is based on the system operators' future activities, which are identified through initial observation of operators' activities in similar situations and iterative

simulations of future activities during the design phase. They provide comprehensive methodological toolkits to observe and analyze activity, to use the data thus collected for specification, to anticipate future activity, to provide recommendations based on the physiological and cognitive characteristics of the users and finally to accompany the system deployment with organizational changes and training actions. The development phase of the system is mostly outside of its scope, the specifications being considered as the solution to the design problem. However, the specifications are not the system, as the map is not the territory. Whatever the quality of the specification-building process, it is unlikely that they will be sufficiently precise, exhaustive, contradiction-free and feasible at the cost of a reasonable effort so that they are all implemented and the solution is exactly in line with expectations and needs. Some authors[2][3] mention this weakness of the link between ergonomics and operational methods of development in the state of the art.

Moreover, in the IT development sector, the same concern to center the process on the user and the satisfaction of his needs has led to the emergence of development methods known as "agile". "An agile method is an iterative and incremental approach to software development, carried out in a very collaborative way by responsible teams, applying a minimal ceremonial, which produce, within a constrained period, a high quality software responding to the changing needs of the users"[4]. These methods promote an iterative, incremental and evolutionary approach and make operational proposals about project management and development team organization and practices so as to be able to integrate new or updated users' requirements during the project lifecycle.

Agile methods are operational methods of computer development. Their product, built with future users (or at least their representatives) is the application itself. Specifications are only a working tool, or even a by-product of the activity. Future users use and evaluate successive versions of the application, incomplete or in any case not finalized, but certainly more representative of the final application than models or inactive mock-ups. The user representative is part of the decision-making committee that examines contradictions between certain specifications, feasibility issues. It can decide on the concrete proposals made by the designers to meet certain needs. The confrontation of points of view is carried out around a concrete object, the current version of the application. Beyond the interaction with the user representative and the decision-making role attributed to him, the organizational aspect of these methods is concerned only with the internal functioning of the development team. The definition of initial requirements the organization of the successive versions' evaluation and the assessment of the results of these evaluations are completely outside the scope of their action. These methodological shortcomings are compensated by the flexibility of the application developed, the strategic bias of iterating up to customer satisfaction, and the rapidity of the iterations, which allows to multiply them in a reasonable time. Nevertheless, we see here the limits of the approach.

Design and prototyping projects were carried out in the PRISME department of EDF R&D by implementing agile development methods and integrating the HOF approach. The agile approach was used in these cases not to respond to changing needs but to meet needs as they emerged, through the use of successive versions of the system by end users during phases of experimentation and exchanges with designers organized at the end of these phases. The projects were led by developers familiar with the principles of ergonomics but without the support of ergonomics specialists.

The positive feedback of these projects led to a more formal definition of an integrated HOF-oriented design and development method, described in this paper.

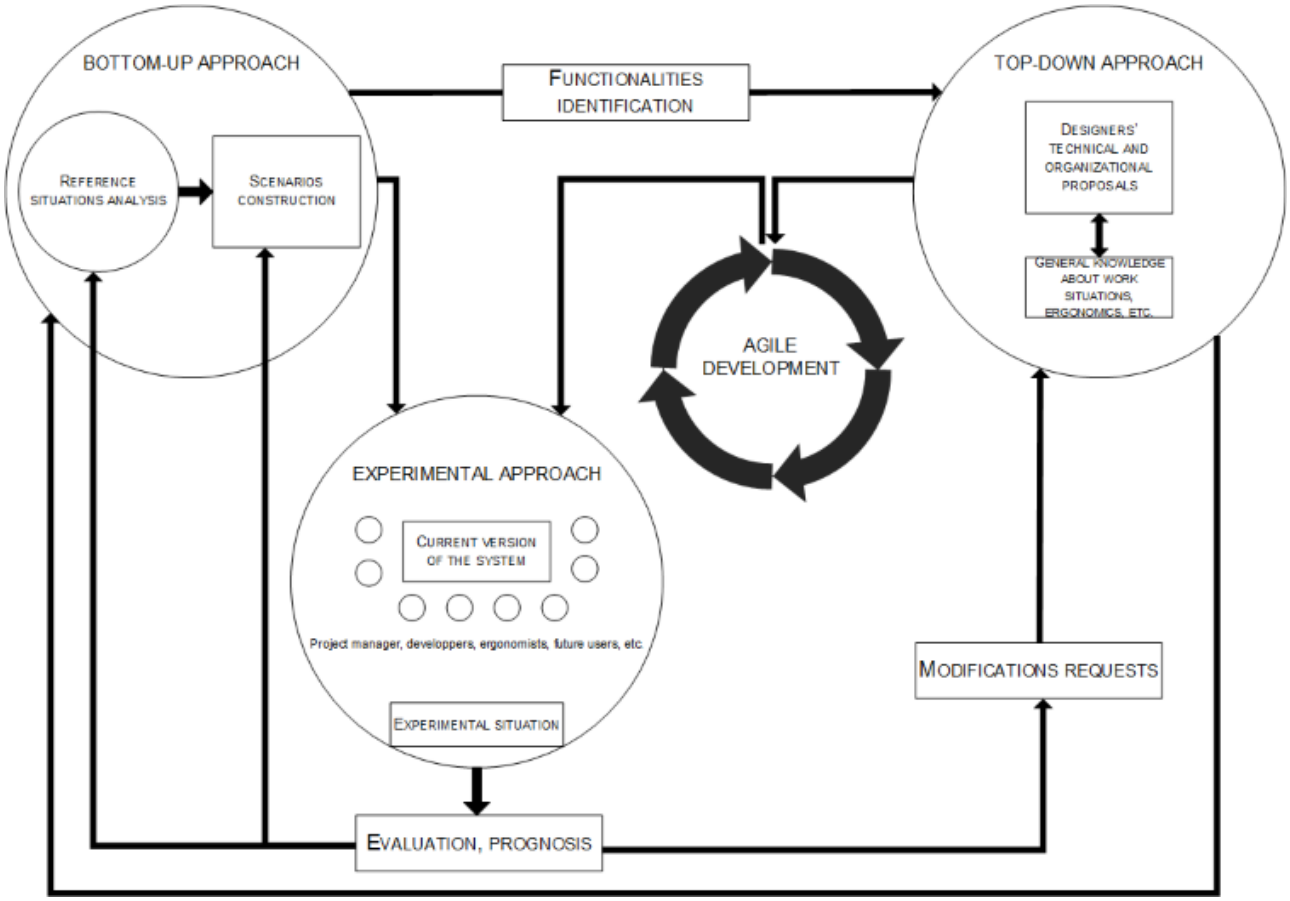


Figure 1 Integrated Human and Organizational Factors–oriented Design and Development Method (Adapted from[5])

## 2 Integrated Human and Organizational Factors –oriented Design and Development Method

The principle of the method is the combination of an agile development and the three complementary approaches (ascending, descending and experimental), which constitute an ergonomic approach in the design process[5] and whose purpose is to feed each iteration of development. The system is developed incrementally, each intermediate release being evaluated in an experimental approach.

The bottom-up approach is centered on the analysis of reference situations, or characteristic actions situations[6]. These reference situations are first constructed from the existing, from the observation of the real work. The target of these observations can be the activity in which will be inserted the system under development or activity on a site or facility in which a similar system is used. These reference situations will then be refined and clarified by evaluating the experiments. The bottom-up approach produces use cases, which are used by the top-down approach to define the functionalities and operating conditions of the future system, and by the experimental approach to build scenarios to be experimented.

The top-down approach's purpose is to identify and refine the objectives of the project, and therefore the expression of needs and then the specifications. It involves initially only the expertise of the ergonomist (knowledge about human functioning, physiological limits, ergonomic standards and good practices, etc.). It is then fed by the other two approaches and implemented by a design team operating according to the principles of agile methods and integrating designers, users and ergonomists. Two decision-making bodies are involved in this phase: the design team and the strategic decision

committee. The strategic decision committee, including representatives of the contracting authority and project management, is responsible for defining the broad guidelines and in particular the functional scope of each intermediate release. This group meets after each simulation phase, to decide on requests for modifications or additions of new functionalities. Three types of decisions can be made: rejection, integration in the next intermediate release, integration in a later intermediate release. The design team meets regularly during the development phase of each intermediate release, to ensure that it meets user expectations and to make decisions within the mandate given by the strategic decision committee. It may also meet at the request of the development team whenever it needs additional information.

The experimental approach is intended to provide a prognosis for future activity around the system being designed. As this activity cannot be observed because the system does not yet exist, it is simulated using the current version in development, delivered to users and experimented by them in the course of their normal activity, in parallel with the actual work, based on the scenarios developed by the bottom-up approach. The ergonomist has a crucial role to play in the preparation and animation of these simulations involving future users. He makes observations on user activity with the system. If problems or deficiencies are observed, changes may be requested on the system under design, organization or user training. The functions and characteristics of validated system during the experimentation will be integrated without changes in the final release of the system.

## 3 Organizational Principles

The proposed approach is iterative, collective and participative. It therefore requires:

- A strong project manager, who intervenes in the project throughout its development, from the preliminary design to the start-up of the installation,
- A precise articulation between contracting authority and project management, at all stages of the project,
- The organization of end-user participation through experiments,
- The organization of the different points of view of the project stakeholders and arbitrations at key stages of the project, especially with each iteration, previously identified and precisely phased.
- A construction of collective work.

The contracting authority must first of all strengthen its competencies, in particular at the HOF level, to enable it to define and implement the sociotechnical objectives of the project. Since the stakes and objectives of the project are diverse, it is generally necessary to set up a project management collective whose composition must make it possible to represent all the logics that will have to be taken into account in the project. The proper functioning of this collective of course requires the designation of arbitration mechanisms (and in particular a member of the collective responsible for the role of arbitrator) to decide in the event of disagreements within the collective. These disagreements are not only probable but desirable to identify and refine the objectives of the project. Initially, the role of this collective will be to enrich the initial objectives of the project, relying on HOF experts.

On the basis of the fact that the problem of design cannot be exhaustively defined initially, but is built up gradually, at the meeting point between the research by the project management of feasible solutions and the refinement of the will of the contracting authority, the contracting authority must also be given the means to ensure the pre-eminence of its socio-technical objectives on the purely technical objectives borne by the prime contractor. This implies that the contracting authority must be involved at the operational level and not only at the strategic level. A contracting authority project manager (CAPM) must be appointed.

The second strong idea is the realization that the skills required for the success of the project are too diverse to be the prerogative of a single person or even a single entity. Regular confrontations of the different points of view are therefore necessary to

make the solution emerge. These confrontations must be organized and planned before the project starts. In particular, it is essential to define beforehand by whom and how the arbitrations will be rendered in the event of divergent views, within the collective of the contracting authority, between the contracting authority and the prime contractor and within the design collective.

The design collective is responsible for developing the solution. It includes the CAPM (or his representative), user representatives, the project manager, developers and ergonomists. Arbitrations are rendered by the CAPM, unless consultation with the strategic decision committee is necessary. The design collective is in charge of steering the iterative process and the articulation of the activities of the different teams. The project manager is in charge of the animation of this collective.

Collective work cannot be decreed, it must be the object of a social construction. The precise definition of the roles and responsibilities of each is an essential element of this construction. It can and should be strengthened, especially in the initial stages of the project, by strong animation within the project and by facilitating events.

This approach can of course be applied to any development project. In the case of a project requiring an R&D phase, it can also provide, through its iterative and incremental nature, continuity between the R&D phase and industrialization phase. The project iterations are distributed between the two phases and the operational management of the project is initially carried out by the R&D (in consultation with the future project management) and then transferred to the developer (contractor, internal engineering division…) during the industrialization phase.

# 4 Project milestones

### 5.1 Exploratory study

The exploratory study is carried before to the launch of the project, to analyze the request formulated by the contracting authority. Its main objective is to clarify and enrich the expression of the needs and expectations of the contracting authority.

In detail, it should:

- determine if the development of the system can bring interesting and significant advances,
- determine whether it is possible to treat the need with the constraints of the project,
- define a correct dimensioning of the project,
- achieve an initial level of specifications sufficient for fast convergence of the iterations towards a satisfactory solution.

The study is followed by a breakpoint to judge the appropriateness of continuing the project.

With the exception of very simple cases, it requires the intervention of HOF specialists. Their task will be to carry out a survey of the users concerned and the activities impacted by the new system, taking into account the context and the variability in performing the tasks. This survey of operation situations will be based on three sources:

- the technical options under study,
- the analysis of the current situations on the site (s) concerned by the project,
- the analysis of situations existing on sites that contain solutions similar to those being studied.

Since human work can never be described only as the execution of prescribed procedures, this activity generally requires interviews with users and observations in real work situations.

The exploratory study is the first step in a design and development approach based on activity analysis. It does not require a very high level of detail for itself, but all the information gathered during this study will be useful to the design.

### 5.2 Facilitating events

A good way to launch an iterative development cycle is to organize a facilitating event at the beginning of the project. This event can take many different forms, such as “Hackathon”, “Design workshop”, “Creative workshop”, depending on whether the initial need has been more or less

identified. Its main interest is to federate the design collective at the beginning of the project and to create a dynamic for the project team.
Facilitating events aim at bringing together all the actors participating in the design collective in the same place for a fixed period of time (from two to three days). All the participants will then have as their first objective at the end of this event to produce a model of the proposed solution accompanied by a list of functionalities prioritized by importance.
To be successful, this type of event requires a solid exploratory study and significant preparation work for its organization. Strong support from high level management is also necessary.
This facilitating event is also a very good showcase for communicating about the project underway and may result in the creation of communication or poster presentations filmed the future product.

## 5 Conclusion

This design and development method has been used in several R&D projects in the PRISME department. One of these projects led to design and development of a prototype to improve administrative tagouts management. This integrated system included a monitoring software, a wireless network, wireless padlocks and optionally a PDA. Another example was the prototyping of a mobile application for acoustic measurement campaigns led by a specialist team of EDF Direction Technique Générale.
In both cases, the results were very encouraging. The different actors of the project were convinced of the relevance of the approach and its effectiveness, particularly the end users. They were invested in the process and looked forward to the industrialization of the prototypes because they were convinced that the developed system would provide them with real added value in carrying out their activities.
In light of these successes, several other projects in the PRISME department have been launched using this method. Moreover, a training course is under construction, so as to make the use of this method widespread in the department. As a matter of fact, this method can be applied to design projects of various types. It can be applied to relatively complex systems design projects with various components. Applying it to purely computer-based design projects, compatible with fully agile development methods, seems even more relevant. It can also be applied to the design of less technological and more organizational systems.
However, generalizing this method to larger projects, involving several teams for the design and development of several subsystems, and some contracting issues, remains a subject for future studies.

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